# SCIENCE ABSTRACTS.

## Section A.—PHYSICS

**JUNE 1922.**

## GENERAL PHYSICS.

**1218.** *Automatic Mercury Pump.* **D. F. Stedman.** (Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 93–94, 1921.)—A mercury pump is described which uses as small an amount of mercury as possible, having none of the troublesome 76-cm. connections excepting in the gauge. T. H. P.

**1219.** *Capillary-flow Device for Indicating Variations of Barometric Pressure.* **M. Courtines** and **J. Villey.** (Comptes Rendus, 174, pp. 541–543, Feb. 20, 1922.)—The device comprises a Dewar vessel, the interior of which communicates with the external atmosphere by means of a capillary tube; the variations of external pressure are indicated by a sensitive manometer. The authors discuss briefly the principal factors upon which the accuracy and sensitivity of the device depend.
J. S. G. T.

**1220.** *New Tensile Testing-Machine giving the Elastic Limit and the Modulus of Elasticity.* **R. Guillery.** (Rev. de Mét. 19. pp. 101–108, Feb., 1922.)—The machine is arranged in such a way that increasing stresses tend to make a column of water rise in a gauge glass, while the strains tend to cause the same column of water to fall. The scale of the fall due to the strains is fixed, but the scale of the rise due to the stresses is adjustable in such a way that it is possible to arrange that during elastic deformation there is no change in the level of the water. The setting of this scale gives the modulus of elasticity of the material, while the load at which movement of the liquid is first seen gives the elastic limit.
J. L. H.

**1221.** *Compensation for Elastic Lag.* **K. Bennewitz.** (Phys. Zeits. 22. pp. 329–332, June 1, 1921.)—Describes a method for compensating for the elastic lag in such instruments as the aneroid. The principle lies in coupling together in opposition two instruments with different sensitivities, but having the same lag. The theory of the device, as well as other methods of applying it, are given in the paper. J. W. T. W.

**1222.** *Shock Hardness.* **G. Moreau.** (J. de Physique et le Radium, 2. pp. 329–336, Nov., 1921.)—A mathematical investigation of what happens when a sphere hits a metal (or other) block; a few hardness data obtained from experiments carried out by means of a steel ball falling against various substances; and a study of dynamic hardness measured by the electrical resistance at the area of contact between the sphere and the metal under test. The author shows that the contact is made up of three phases: (1) the phase of penetration during which the ball has a negative acceleration; (2) the phase of reaction, the acceleration being positive; and (3) a passage across a thin superficial layer of air. J. L. H.

**1223.** *Hertz's Theory of the Contact of Elastic Bodies.* **W. B. Morton** and **L. J. Close.** (Phil. Mag. 43. pp. 320–329, Feb., 1922.)—The work of Hertz on the deformations and stresses produced when two bodies, having continuous curvature, are pressed together was developed by Huber, who investigated the case of the contact of two spherical surfaces. Huber's results are expressed in terms of an elliptic coordinate, and are inconvenient for purposes of calculation. By the method of expansion in zonal harmonics, the authors have obtained numerical values of the stresses, etc., in Huber's case of axial symmetry. Graphs are given for the stresses along lines running from the centre of contact in directions making angles of 0°, 30°, 60°, and 90° with the normal. Further, it is shown that the characteristic features of the limiting forms assumed by the lines of principal stress at a distance from the contact can be simply deduced from the solution, given by Boussinesq, of the problem of a body acted upon by a pressure concentrated at a point on an otherwise free plane boundary. J. S. G. T.

**1224.** *Stability of a Rotating Shaft, Subjected Simultaneously to End Thrust and Twist.* **R. V. Southwell** and **B[arbara] S. Gough.** (British Association Complex Stress Committee Report, pp. 345–355, 1921.)—The criterion of stability for a long shaft, with "simply supported" ends, subjected simultaneously to end thrust and twist, was given by Greenhill in 1883, and the corresponding criterion, when the disturbing factors are end thrust and rotation, is well known; but the problem which is presented when the three actions occur simultaneously does not appear to have been solved. Solutions are obtained in this paper both for a "simply supported" and for an *encastré* shaft. The treatment is mathematical throughout. From the formula derived by the authors, and a similar approximation for the *encastré* shaft, it may be concluded that the relative importance of end thrust, rotation and twist is of the same order, when the three actions occur simultaneously, as it has been shown to be when they are taken as acting in pairs; that is to say, any torque which a shaft of ordinary dimensions can sustain without damage to the material will be negligible in its effect on the stability of that shaft. AUTHORS.

**1225.** *Experimentally Established Facts concerning the Turbulence Problem.* **L. Schiller.** (Phys. Zeits. 23, pp. 14–18; Disc., 18–19, Jan. 1, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—Experiments to determine the critical Reynolds number for flow through tubes have given results from 200 (Rucker) to 25,500 (Ekman), and this wide divergence raises the question whether there is a unique critical number. The formula involves only one length, usually taken to be the radius of the tube, but the length of the tube must have some effect, as the basis of the formula is dynamical similarity. To this is traced

a variation from 1200 to 1700 between long and short tubes. By bringing a plate nearer and nearer to the inlet, the Reynolds number at which turbulence commenced dropped from 6000, when it was 20 cm. away, to 1160 when it was $1\cdot2$ mm., but no further reduction was caused by nearer approach. It was also found that with a rounded inlet, but a rough tube, laminar flow could be obtained for R 9000, so that ordinary roughness plays no part in determining the rise of turbulence. It is therefore concluded that there is a critical number, 1160, below which the laminar flow is absolutely stable. The existence of an upper limit, above which laminar flow is impossible, is an open question, but appears doubtful. **R. v. Mises** pointed out the analogy between Ekman's 25,500 and the possibility of cooling water to $-40°$ without it solidifying. **L. Hopf** said that although the velocity in the neighbourhood of the walls is small, yet vortices may be originated by roughness, and thus cause the turbulence.
W. G. B.

**1226.** *Two-dimensional Slow Motion of Viscous Fluids.* **L. Bairstow [Miss] B. M. Cave,** and **[Miss] E. D. Lang.** (Roy. Soc., Proc. 100. pp. 394–413, Jan. 2, 1922.)—An extension of the methods of a previous paper [Abs. 980 (1919)] to obtain solutions of the equation $\nabla^4\Psi = 0$. The solution is obtained in terms of definite integrals taken round the boundary of the region considered, and these can be evaluated by graphical or mechanical methods. As an instance of the application of these methods to a doubly connected region, the slow motion of a viscous fluid through a parallel-walled channel and past a circular cylinder is worked out in detail. Stream-lines and lines of constant molecular rotation are plotted. The resistance of the cylinder is also calculated. W. G. B.

**1227.** *Flow of Viscous Liquids through Slightly Conical Tubes.* **A. S. Hemmy.** (Phys. Soc., Proc. 34. pp. 22–25; Disc., 25–26, Dec., 1921.)—A formula is obtained for the flow of a viscous liquid through a slightly conical tube by neglecting terms containing the square of the obliquity. The approximation is shown to be justified by the agreement in the values of the viscosity found experimentally with tubes of differing degrees of conicality. AUTHOR.

**1228.** *The Design of Screw Propellers and the Analysis of Trial Results.* **W. J. Duncan.** (Inst. Eng. and Shipbuilders, Trans. 65. pp. 112–140, Feb., 1922.)

**1229.** *Analysis of Propeller Performance.* **C. Macmillan.** (Inst. Eng. and Shipbuilders, Trans. 65. pp. 57–111, Feb., 1922.)

**1230.** *Turbulence and Velocity Distribution in Water-courses.* **F. Ahlborn.** (Phys. Zeits. 23. pp. 57–65, Feb. 1, 1922.)—Well illustrated but unsuitable for abbreviation. L. H. W.

**1231.** *Aerodyamics of a Spinning Shell.* II. **R. H. Fowler** and **C. N. H. Lock.** (Roy. Soc., Phil. Trans. 222. pp. 227–247, March 15, 1922.)—This second part analyses the unstable rounds not dealt with in the earlier paper [Abs. 985 (1921)]. L. H. W.

**1232.** *Coupled Variations by Means of a Double Pendulum.* **A. L. Narayan.** (Phil. Mag. 43. pp. 567–574, March, 1922.)

**1233.** *Mechanical Illustration of Three Magnetically Coupled Oscillating Circuits.* **A. L. Narayan.** (Phil. Mag. 43. pp. 575–580, March, 1922.)—Deals with a pendulum apparatus on the lines of that of Barton and Browning, but having three pendulums. L. H. W.

**1234.** *Note on Gravitation; Experimental Test.* **O. W. Richardson** and **L. Simons.** (Phil. Mag. 43. pp. 138–145, Jan., 1922.)—Experiments have been undertaken to seek a connection between gravitation and electricity. The idea is that gravitation may be due to a slight modification of the law of force between positive and negative electrons, such modifications arising out of the different amounts of energy associated with these electrons as evidenced by their different masses. One consequence of this view is that the ratio between weight and mass should not be quite the same for different elements. No positive results have been obtained. The theory is given by O. W. Richardson. An appendix by L. Simons describes the experiments. A very light silica balance (weighing 4 gm.) was placed in a metal box. Horizontal Al vanes were carried by each arm of the balance and could be charged to any potential + or − up to 1000 volts. The vanes are a short distance above, and parallel with, two plates, and the attraction between vanes and plates was observed by telescope and mirror (on the balance). No difference in attraction was observed whether the vanes were charged positively or negatively. P. E. S.

**1235.** *Remarks on Relativity.* **L. Lecornu.** (Comptes Rendus, 174. pp. 337–342, Feb. 6, 1922.)—A recent work by G. Moch on "Relativity of Phenomena" states the classical principle of relativity. Thus, "The laws of nature are the same for observers who are in uniform motion of translation with respect to each other." The author gives an example to show that this is incorrect and is due to a confusion between the principle of relativity and that of the independence of the effect of a force and the velocity of its point of application. In the same book objection is made to a statement by M. Lecornu in his work on "Ideas and Facts of Mechanics" that the secular acceleration of Mercury's perihelion is only 38″ and not 43″, so that Einstein explains 13 % too much. The author quotes recent work in support of the 38″, as against Le Verrier's 43″. He also states that such an acceleration can be explained by the intervention of a force proportional to the velocity and acting in the plane of the orbit perpendicular to the motion. He mentions some instances of similar forces in mechanics, such as the gyroscopic theory, and in electro-dynamics, and suggests that the Einstein displacement might be due to some combined action of a force of this kind and that of Newtonian attraction. To test this he considers a case where unit mass in a plane is acted on by two such forces and obtains a law resembling that of the action of a magnet on a movable electric charge, as if one of the forces might be due to the magnetisation of the sun. His attempt to make this law fit the displacement of Mercury's perihelion and the deviation of light-rays meets with such difficulty that he is driven to suppose the phenomena close to the sun to be much more complicated than he had assumed. He then appeals to Gauss' principle of least constraint and the assertion of Hertz that no action can take place at a distance, so that there must be a medium (the ether) making contact, and he hopes that this principle of least constraint will account for astronomical phenomena without doing violence to our notions of space and time. (Errata: *Ibid.* p. 504, Feb. 13, 1922.) W. W. B.

**1236.** *Ricci's Principal Directions for a Riemann Space and the Einstein Theory.* **L. P. Eisenhart.** (Nat. Acad. Sci., Proc. 8. pp. 24–26, Feb., 1922.)

**1237.** *Physical Basis of Atomic Radiation.* **E. Gehrcke.** (Zeits. f. Physik, 6. 5 and 6. pp. 400–402, 1921.)—A brief discussion of the modern views of atomic structure and the ether of the old Maxwellian theory, as relating to the theory of atomic radiation. A. B. W.

**1238.** *Anisotropy of Molecules.* **C. V. Raman.** (Nature, 109. pp. 75–76, Jan. 19, 1922.)—Evidence that the molecules of gases are not spherically symmetrical and are anisotropic in their properties is furnished by the recent experiments of Rayleigh on the scattering of light. Rayleigh's method of observation was photographic, but direct visual observation and measurements have been made by K. R. Ramanathan by using the strongest possible illumination (sunlight), securing a perfectly black background, and very carefully screening the eye from extraneous light. In this way it has been found possible to detect with dust-free air at atmospheric pressure the non-extinction of the track as seen through a nicol at any orientation. With $CO_2$ the effect is quite conspicuous, and visual determinations of its magnitude have been made. Observations on the polarisation of skylight were made from the summit of Mount Dodabetta, in the Nilgiris (8750 feet above sea-level), the sky being very clear and appearing almost black through a deep red filter. The weaker component of polarisation was found to have 13 % of the intensity of the stronger component. Diffuse illumination of the sky is capable of explaining only a part of this, a weaker component of about 8 % being indicated by the calculations. The residual 5 % must therefore be ascribed to molecular anisotropy, and this is in agreement with Rayleigh's laboratory determinations. Observations on the molecular scattering of light in *liquids* also show an imperfect polarisation attributable to anisotropy. Experiments in the same direction with crystals are in progress. A. W.

**1239.** *Determination of Molecular Diameters.* **C. E. Guye** and **R. Rüdy.** (Comptes Rendus, 174. pp. 382–384, Feb. 6, 1922.)—It has previously been shown that in the case of the rotation of an electric discharge in a magnetic field the velocity of rotation is given by $V = eH/(12\pi\sigma^2 Nm)$, where $e$ is the charge on the ion of mass $m$, N the number of molecules per unit volume, H the intensity of the magnetic field, and $\sigma$ the molecular radius, assumed equal to that of the positive ion [see Abs. 369 (1922)]. When the pressure of the gas in the discharge tube is progressively varied, the discharge passes through several stages. The product of the pressure and the velocity of rotation is only constant for a certain range of pressures, the limits of this range being in general not far apart. Within these limits, however, the formula given above is applicable, and the velocity of rotation is accurately proportional to the magnetic field. With impure gases the formula does not hold, and in all cases rigorous methods were employed to purify the gases used. The measurements give values of the molecular radii in good agreement with the figures determined from viscosity experiments. The following table gives the molecular diameters determined for the gases used :—

| Gas. | $O_2$. | $N_2$. | $CO_2$. | $H_2$. | $N_2O$. | $CH_4$. | CO. |
|---|---|---|---|---|---|---|---|
| $2\sigma \times 10^8$ (Rotation) . | 3·25 | 3·27 | 4·04 | 2·21 | 4·04 | 3·70 | 3·88 |
| $2\sigma \times 10^8$ (Viscosity) . | 3·19 | 3·27 | 4·1 | 2·38 | 4·1 | 3·6 | 3·36 |

A. W.

**1240.** *Encounters between Non-spherical Gaseous Molecules.* **A. O. Rankine.** (Phys. Soc., Proc. 33. pp. 362–376, Aug., 1921.)—An extension of previous work, the limitation that the atoms building up the molecules are all of equal size being now removed. L. H. W.

**1241.** *Transition Elements and the Octet Theory.* **R. G. W. Norrish.** (Chem. News, 124. pp. 16–22, Jan. 13, 1922.)

**1242.** *Structure of Atomic Nuclei.* **O. Chwolson.** (Zeits. f. Physik, 7. 4 and 5. pp. 268–284, 1921.)—A theoretical paper not permitting of concise abstraction. A. B. W.

**1243.** *Deductions from the Spherical Form of the Atom.* **L. Zehnder.** (Phys. Zeits. 23. pp. 53–55, Jan. 15, 1922. Paper read at the Deut. Physikertag., Jena, Sept., 1921).—General considerations of modern theories of atomic structure and the ether. A short abstract is not possible. A. B. W.

**1244.** *Positive-Ray Analysis of Lithium and Magnesium.* **A. J. Dempster.** (Phys. Rev. 18. pp. 415–422, Dec., 1921.)—*Isotopes of lithium and magnesium* have been *determined by positive-ray analysis,* using the apparatus and method previously described. The source of the rays was a small cylindrical anode containing the metal to be studied, which was heated by a concentric coil and bombarded by electrons. It was found that there are two isotopes of lithium with atomic weights 6 and 7, while Mg has three isotopes with atomic weights 24, 25, and 26. The relative proportions of the isotopes of Li varied with the conditions. For Mg the relative numbers were 7 : 1 : 1.

*Compensation Method of Measuring Small Currents.*—The current to be measured is balanced by the current through an ionisation chamber, which is adjusted to equality by varying the width of the slit through which the ionising $\beta$-rays pass. AUTHOR.

**1245.** *Structure of Atoms, particularly of the Helium Atom.* **R. A. Millikan.** (Phys. Rev. 18. pp. 456–460, Dec., 1921.)—*Discussion of suggested models for helium and other atoms* in the light of recent results of a study of multiple ionisation by $\alpha$-rays. As will be reported more fully elsewhere, it has been found that slow $\alpha$-rays detach both electrons from some of the helium atoms through which they pass, the number of doubles being one-sixth the number of singles, while in the case of the other gases tested no evidence of multiple ionisation has been obtained. The result is considered by the author to indicate that the electronic orbits in the helium atom must be such as to bring the two electrons into the same part of the atomic volume at least one-sixth of the time, a condition which is well satisfied by the recent models of Landé and Bohr in which the orbits cross each other. In the case of other atoms the new evidence favours the Bohr models, with few electrons in the outer shells.

*Multiple ionisation in arcs and sparks is probably due* to successive ionisation of the same atoms. AUTHOR.

**1246.** *Structure of Organic Crystals.* **W. H. Bragg.** (Phys. Soc., Proc. 34. pp. 35–50, Dec., 1921.)—For many reasons the structure of crystals of organic substances invites examination by the methods of X-ray analysis; but their molecular complexity would seem to throw great difficulties in the way. It is possible, however, that the difficulties in the case of aromatic compounds may be surmounted by adopting a certain hypothesis, viz., that the benzene or naphthalene ring is an actual structure, having definite size and form, and that it is built as a whole into the organic substances in which it occurs. Reasons can be given why this is *a priori* probable. The examination of certain organic crystals has been made. The results are in general agreement with the hypothesis, and lead to various deductions of interest. AUTHOR.

**1247.** *Behaviour of Pilot-Balloons at Great Heights.* **N. K. Johnson.** (Roy. Meteorolog. Soc., J. 48 pp. 49–57; Disc., 57–59, Jan., 1922.)—Considers nine pilot-balloon ascents followed by the double-theodolite method to determine the magnitude of errors in the single-theodolite method. From experiments on the leakage of pilot-balloons, it is deduced that the cessation of ascent and subsequent descent of four of these ascents is probably due to the development of pinholes without bursting. The results indicate that pinholes may be expected to develop at heights of the order of 20,000 ft.; hence the results obtained for greater heights with a single theodolite must be received with caution. A. W. L.

**1248.** *Displacement of Isallobaric Systems and the Direction of Cirrus Movement.* **L. Besson** and **H. Dutheil.** (Comptes Rendus, 174. pp. 237–240, Jan. 23, 1922.)—This paper contains further notes on the charts of mean conditions over Europe associated with the occurrence of cirrus cloud at Paris [see Abs. 747 (1922)], being devoted particularly to the mean isallobaric charts corresponding to cirrus from different directions. The areas of rise and fall shown on these are mostly elongated, their orientation, as indicated by the direction of the major axis, varying with the direction of cirrus movement. For cirrus with a southward component the axis is veered through an acute angle from the line of cloud motion, and for cirrus moving with a northward component it is backed through an acute angle (with the exception of cirrus from S.E.). In the former case the cloud in general moves from a region of falling barometer to one of rising barometer, and in the second case the reverse holds. The above results were combined in a simple rule in the preceding paper [*loc. cit.*]. The isallobaric systems move approximately perpendicular to their axis, the mean speed, all cases considered, being roughly 40 km/hour (the mean speed of cirrus cloud at Paris, estimated from nephoscope observations, is 88 km/hour). The mean distance between centres of adjacent areas of rise and fall is 1300 km., giving, with the above speed, a period of 2·7 days. Attention is called to a singularity in the case of cirrus from N.W., with which two entirely different types of pressure variation are associated. M. A. G.

**1249.** *Indications of Cirrus in Weather Forecasting.* **P. Schereschewsky** and **P. Wehrlé.** (Comptes Rendus, 174. pp. 314–316, Jan. 30, 1922.)—It is a matter of common observation that cirrus cloud often precedes rain. The authors seek to exhibit the true relationship by referring the cirrus to the " cloud-system " of which it always forms a part. This procedure is regarded as more logical than referring the cirrus to pressure systems. The term *système nuageux* has been applied by Schereschewsky to a group of clouds covering a wide area and so related that the whole can be regarded as a single entity whose development and travel can be traced on successive synoptic charts [see Abs. 58 (1922) and Comptes Rendus, 172. p. 1429]. Various sectors of such a system are recognised, the " front," " corps " and " traîne," and on either side, with reference to the line of advance, a " marge." Each sector has its own characteristics, but cirrus is common to all except the central region or " corps" where the low cloud and rain are located. Though cirrus may take a number of forms, they are typical of the " system " (cyclonic, thunderstorm) rather than the " sector," so that except in the immediate front of the " corps " where the cirrus is thickening to cirro-stratus, an isolated observer of cirrus cannot tell whether he will experience the rain of the " corps " or is merely on the margin of the system. Further, the rate of cirrus movement gives no definite clue to the rate of advance of the " corps," which is found to agree rather with the wind speed at some intermediate altitude. True indications on these points can only be obtained from synoptic charts. M. A. G.

**1250.** *Nocturnal Radiation and Solar Radiation at High Levels.* **A. Boutaric.** (Ann. de Physique, 17. pp. 54–87, Jan.–Feb., 1922.)—Observations of nocturnal and solar radiation made on the Pic du Midi (2859 m.) in Aug., 1919, are given and discussed. The intensity of nocturnal radiation $r$ has been shown by the author to be approximately given by the formula $r = \pi\sigma\theta_0^4 F(f_0)$ [see Abs. 1375 (1920)]. Values of $F(f_0)$ are calculated and shown to be approximately equal to the observed values of $r/\pi\sigma\theta_0^4$. Comparing these observations with those previously taken at Montpellier, the author shows that the nocturnal radiation is not sensibly stronger at a high altitude than at sea-level, when the temperatures and vapour pressures are comparable; this does not agree with observations made by Martins. Observations of $r/\pi\sigma\theta_0^4$ for different stations are generally within 10 % of the values of $F(f_0)$; inversions of temperature are suggested as being the cause of these deviations. Observations for calm nights are shown to follow the same law of variation as the author's observations at Montpellier [Abs. 605 (1921)].

The portion dealing with solar radiation appeared in a previous paper [Abs. 53 (1922)]. A. W. L.

**1251.** *Measurements of Atmospheric Radiation During the Day on Mont Blanc.* **A. Boutaric.** (Comptes Rendus, 174. pp. 183–185, Jan. 16, 1922.) —The author has shown by direct experiment at Montpellier that on very clear days a black surface turned towards the zenith and shielded from direct solar radiation loses heat. The present note describes further measurements on Mont Blanc (4350 m.) during the period July 30–Aug. 7, 1921. Employing, as before, a thermopile placed vertically with one set of junctions towards the zenith and the other towards a bright sheet of metal at the temperature of the surrounding air the author found as the mean resultant radiation from a black surface towards the whole hemisphere (direction of sun excepted) at 13 h. 35 m. (solar time) the value 0·175 gm. cal. cm.$^{-2}$ min.$^{-1}$. This agrees well with the values 0·19 gm. cal. at 13 h. and 0·16 gm. cal. at 14 h. obtained recently by Vallot on Mont Blanc by an indirect method [see Abs. 56 (1922)]. With the appearance of cloud or fog the resultant radiation from the black surface changed sign.

*Short-Wave Radiation.*—Preventing the passage of long-wave radiation by placing a glass screen over the thermopile, the following values were obtained for the short-wave radiation received from the whole hemisphere (region of sun excepted).

0·052 gm. cal. cm.$^{-2}$ min.$^{-1}$ at 11 h. 15 m.
0·019 ,, ,, ,, ,, 14 h. 25 m.
0·000 ,, ,, ,, ,, 16 h. 15 m.

M. A. G.

**1252.** *Physical Structure of Cloud-Form in the Lower Atmosphere.* **R. F. Granger.** (Roy. Meteorolog. Soc., J. 47. pp. 271–279; Disc., 279–281, Oct., 1921.)

**1253.** *Latitude Variation, Ukiah.* **W. D. Lambert.** (Washington Acad. Sci., J. 12. pp. 28–43, Jan. 19, 1922. Paper read before the Philosoph. Soc., Washington.)—The latitude of Ukiah, California, appears to be shifting at the annual rate of + 0″·0081 per annum, but the observations and calculations relate solely to a period from 1900 to 1917. There are now many examples in which the rate is of this order of magnitude, and they are all, without one exception, positive.

*Shift of Pole.*—Lawson's explanation that this variation is due to a northward creep of the crust is rejected. A partial explanation is found in an increasing error in the declinations used. The remainder of the variation is explained as due to a shifting of the North Pole towards the American continent, for this alone would explain why the latitudes are increasing much faster in the American continent than elsewhere. Shifting of mass due to denudation is quite insufficient to cause the shift; but the quantity is of the order required by Darwin's investigation into the possible shift brought about by widespread though slight elevations of the earth's crust during a geological period. Finally, it is found that there is a possibility of obtaining data on the figure of the earth from latitude observations. W. A. R.

**1254.** *Sun-Spot Periodicity and Movement in Latitude explained by Pulsation of Nucleus.* **E. Belot.** (Comptes Rendus, 174. pp. 283–285, Jan. 30, 1922.)—Pursuing his researches on solar rotation [Abs. 69 (1922)], on the analogy of a pulsating Cepheid [see Abs. 385 (1921)], the author deals with a difficulty experienced by Faye, who tried to explain Carrington's law by the hypothesis of an ellipsoidal nucleus, which is contrary to

Clairaut's theory. The author's suggestion is that the spheroidal nucleus pulsates alternately at the equator and the poles, the equatorial pulsation being only half the polar one. He then proceeds to explain how the eleven-year period has been evolved from one of a few days only. The present course of events he considers to be a swelling of the equatorial portion for 3·7 years and a shrinking, while the polar diameter increases, for 7·5 years, giving reasons for the limiting latitude of sun-spots and their rare occurrence actually at the solar equator. The maximum excess of the polar over the equatorial radius was found at Meudon to have taken place in 1907. The gradual damping down of the oscillations of a coiled spring supplies him with an analogy in the absence of a complete theory of pulsation of gaseous spheres, and he finds a formula involving the masses and weights of the pulsating body and the condensed deposit on it, which is originally zero. At first he takes $10^{-5}$ for the density of the proto sun, with its equatorial diameter 62 times its present value, the pulsation being then confined to a thin layer. It becomes effective to increasing depths, with the result of slowing down the pulsation, so that by the time the density has increased to its present value of 1·41 the duration has become eleven years. He remarks that the pulsation periods of Nova Persei and Nova Aquilæ have already increased from original values of 5 to 9 days, to about 50 days. W. W. B.

**1255.** *Orbits of Spectroscopic Components of Boss* 4622. **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 16. pp. 9–11, Jan., 1922.)—This star (position for 1900: 18 h. 13 m. + 56° 34′), of 6·4 mag. and type F0, was found by the author to be a spectroscopic binary in July, 1919, since when 60 plates have been secured, 48 of which show both sets of lines. The range in velocity is more than 200 km. per sec. for each, so that the elements are probably well determined. A difficulty was found since the period is close to 2 days, but the final value is given with confidence as 2·0476 days. The projected major axes of the orbits are each about 6 million km., and the masses about equal to the sun. The hypothetical parallax would appear to be 0″·016. W. W. B.

**1256.** *Time-Determination at Different Observatories.* **R. A. Sampson.** (Roy. Astron. Soc., M.N. 82. pp. 215–225, Jan., 1922.)—In amplification of a previous paper [Abs. 344 (1921)] dealing with Edinburgh only, the author now deals with wireless comparisons of Paris with Edinburgh, Greenwich, Nauen (Berlin), Annapolis (Washington), and Uccle. He compares each observatory with the mean of the six determinations so that the individual errors are almost isolated, making it possible to trace them back to the original transit-observations with a view to explaining how they arise in each case. Curves are given to illustrate these peculiarities, which show considerable variations from time to time. The author discusses the bearing of these on longitude determinations, and concludes that the customary precaution of interchange of observers does not provide a sufficiently accurate elimination of personality. At Edinburgh in particular he finds a seasonal variation, for which he suggests various possible causes. W. W. B.

**1257.** *Long-Period Inequalities in Motion of Asteroids with Mean Motions Nearly Half that of Mars.* **W. M. H. Greaves.** (Roy. Astron. Soc., M.N. 82. pp. 149–168, Jan., 1922.)—Starting with simplified disturbing function, including only the chief long-period terms due to Mars and the chief non-periodic terms due to Jupiter, and treating separately inequalities depending on (1) eccentricity of asteroid, (2) eccentricity of Mars, (3) Jupiter (secular), the resulting formulæ are applied to the selected asteroids (44) Nysa, (67) Asia, (142) Polana, and (182) Elsa, whose mean motions are nearly equal to half that of Mars. The author's conclusions are :—Their motions are subject to long-period inequalities due to the near commensurability with Mars. One of the two chief terms in these involves the eccentricity of the asteroid as a factor, and the other that of Mars. Long-period inequalities also arise from the same cause in the major axes and in the eccentricities. The secular inequalities due to Jupiter do not affect the major axes, but have a greater effect on the eccentricities than the Mars terms. W. W. B.

**1258.** *Stars of β Canis Majoris Type.* **F. Henroteau.** (Roy. Astron. Soc. Canada, J. 16. pp. 58–61, Feb., 1922.)—Apparently spectroscopic binaries of very short period (3 to 6 hours), it is not certain that these stars are real binaries. Before 1920 the class included only three others besides the patterns, β Cephei, σ Scorpii and 12 Lacertæ, and each of these has distinctive peculiarities. The author has sought for other examples since the latter part of 1919, under great difficulties, and now gives a list of 24, including the original four, some of which, however, are only suspected members. Suggested hypotheses, in case there is a common cause, are: (1) binaries in formation; (2) rotating Jacobean ellipsoids; (3) peculiar loops in close systems of 3 or more bodies. W. W. B.

**1259.** *Proper Motions of 154 Red Stars.* **R. E. Wilson.** (Astron. J. 34. pp. 23–28, Feb. 20, 1922.)—The stars are mostly classified as Md, R and N, the remainder being Mc variables and a few red stars with peculiar spectra not yet classified; 116 of the proper motions are new. Full details are tabulated. The proper motions of the Md stars are in general small, but their radial motions are large. They must therefore have large actual motions and be very distant giants, or most of them. The proper motions of N stars are generally small, as also their radial velocities, so they are slow-moving stars as a class. The red stars follow the general tendency of other stars in preferential motion towards Kapteyn's vertex, the velocity figure being approximately that of an ellipsoid of revolution slightly flattened possibly towards a plane at right angles to that of the galaxy. [See Abs. 806 (1921).] W. W. B.

**1260.** *New Theory of the Formation of Spiral Nebulæ and of the Solar System.* **T. Moreux.** (Comptes Rendus, 174. pp. 598–601, Feb. 27, 1922.)—The theory that novæ are due to the collision of a star with a gaseous mass at a low temperature leads to results in conflict with Maxwell's laws. To avoid this difficulty the author proposes to substitute a cloud of meteors (inelastic solid bodies) for the gaseous mass. He divides these meteors into two divisions, according as they actually collide with the star or only come within its sphere of action, and considers the subsequent motions. He concludes that if the general duration of the swarm is perpendicular to the axis of rotation of the star, two spirals will form about the equator and condensation will continue until the whole swarm falls to the centre, forming a simple giant star without any planets. If, however, the motion is inclined to the axis of rotation, the first few meteors captured will string out round the equator, but the more distant ones will be less and less affected and will tend to remain in the plane of their original motion. He thus supposes two ellipsoidal condensations, the interior one conforming to the plane of rotation of the star, while the outer one retains that of the cosmic cloud. He finds in this an explanation of the relatively small inclinations of Mercury and Venus, and of the large size of the external planets, also a dynamical basis for Bode's law and a plausible origin for comets. W. W. B.

**1261.** *Dearborn Measures of Stellar Parallax.* **P. Fox.** (Comptes Rendus, 174. pp. 595–598, Feb. 27, 1922.)—The present list is of 34 stars. Special attention is drawn to Nos. 5 and 25 as belonging to the Monoceros stream; to No. 7, Furuhjelm's companion to Capella; to No. 22, Barnard's proper-motion star; to No. 21, the double star $\Sigma 2128$. Two observers have measured the last named, and find identical proper motion but different parallaxes. W. W. B.

**1262.** *Note on Masses of the Stars.* **H. N. Russell and D. L. Webster.** (Roy. Astron. Soc., M.N. 82. pp. 181–182, Jan., 1922.)—According to Eddington's theory, stellar masses are limited by fundamental constants of Nature. A gaseous mass can shine as a star only when the internal radiation-pressure is a sensible fraction of the whole pressure, but if this fraction is too great the mass tends to break up into smaller stars. Jeans has put the equation from which this is derived into a form which the authors use, involving expressions admitting of simple physical explanation, one being the number of molecules in the star and another the ratio between the gravitational attraction between two molecules and the electrostatic repulsion between two electrons at the same distance. A third quantity is a number varying from point to point, depending on the internal constitution of the star. Assuming Eddington's theory and using Emden's data, the authors derive numerical values, and conclude that a mass of gas will appear as a star if the ratio of the radius of the mass to the average distance between the molecules is between 5 and 30 times the ratio of the unit electric charge to the average mass of a molecule, the mass being measured in the same manner as the charge. If any other model than Eddington's be adopted, the figures will not be altered much. In the extreme case of uniform density they will be increased not more than 50 %. The conclusion appears to be general, and results of the same order of magnitude would have been reached without using any observed masses of stars. W. W. B.

**1263.** *Solar Motion from 1922 Radial Velocities.* **G. Forbes.** (Roy. Astron. Soc., M.N. 82. pp. 174–177, Jan., 1922.)—The data used are those of Voûte's First Catalogue of radial velocities, omitting the 138 nebulæ, 10 clusters and 1 star (Barnard's) with very discordant values. Of the 1922 remaining radial velocities, 697 are greater than a solar motion of 20 km./sec. These show a great concentration of + velocities from galactic longitude 110° to 270°, including an oval patch about 90° in diameter containing 197 + and only 4 − values. The opposite hemisphere is full of − with very few + values, including an oval patch of 205 − and 19 + stars. The centre of − concentration may be at galactic longitude 30°, latitude 10°; that of + concentration in latitude − 10° to − 20°, longitude uncertain. These are practically independent of solar motion, and indicate Kapteyn's stream I. The method of deducing the solar motion is given by Campbell in "Stellar Systems," and this the author follows, except that he rejects nothing with any definite idea of improving the solution. His least square solution gives solar motion 22 km./sec. in direction R.A. 270°, Decl. + 27°. W. W. B.

**1264.** *Interferometer Measures of the Diameter of Stars whose Surface Brightness is not Uniform.* **M. Hamy.** (Comptes Rendus, 174. pp. 342–345, Feb. 6, 1922.)—In his work on diffraction [see Abs. 1254 (1920)] the author has obtained a formula for the brightness near the limb, which fits very well for the sun, and considers the effect of the falling off towards the limb in the case of interference measures of stellar diameters. He describes the method used at Mount Wilson as well as Fizeau's earlier idea. He thinks it possible to determine not only the actual diameter, but also the radial variation of brightness, and works out a scheme for doing so. The problem leads to the solution of a transcendental equation, which will require numerical substitutions. He hopes the method will be applied to Betelgeuse, since the result should be all the more interesting as it is almost impossible to conceive the atmospheric conditions for so vast a star so little advanced in condensation. W. W. B.

**1265.** *Star-Streams.* **E. E. Barnard.** (Roy. Astron. Soc. Canada, J. 16. pp. 51–53, Feb., 1922.)—Photographs of the sky, especially those made with portrait lenses, often show apparent lines of stars of nearly equal brightness, the lines being straight or curved and sometimes of considerable extent. The author suggests that this is very likely a real effect due to some hypothetical sweeping effect. He gives some instances from the Milky Way, and thinks that a common drift in some regions is very probable. None of the measured proper motions of stars can be adduced in explanation, as they are all of brighter stars, while the drifts in question are in distant parts of the Milky Way and the stars as a rule fainter than 12th magnitude. W. W. B.

**1266.** *Projection of Light of Binary Stars and Oscillations of Rays of Spectrum.* **G. Sagnac.** (Comptes Rendus, 174. pp. 376–378, Feb. 6, 1922.)—Radial-velocity observations depend on displacement of rays, proportional to wave-length; thus $\Delta\lambda/\lambda$, which corresponds to $\Delta\nu/c$, where $\Delta\nu$ is radial velocity and $c$ the normal velocity of light. Cepheids and similar stars (cluster variables and those of $\beta$ Lyræ type), in which the rise to maximum is about twice as quick as the fall to minimum, have their maximum brightness nearly coincident with max. radial velocity. The author considers that the slight want of coincidence is due to the projection of energy in combination with the radial velocity, an effect not appreciable with the photometer but only in the spectroscope. He suggests classification of these stars not only by the period from maximum to minimum brightness, but also by the duration of the complete variation of radial velocity, the minimum being taken at zero velocity and the maximum towards red or violet, according to direction of motion. By this method he claims to calculate the dissymmetry of the light-curve, which he has found in computed examples to agree with that observed. W. W. B.

## LIGHT.

**1267.** *An Auto-Stroboscope and an Incandescent Colour Top.* **F. L. Hopwood.** (Optical Soc., Trans. 23. 2. pp. 93–98, 1921–1922.)—A description is given of some novel optical phenomena which may be observed when revolving incandescent filaments are viewed. The first portion of the paper deals with objective phenomena and the latter portion with subjective phenomena. In Part I the production of a variety of stationary dark images, due to the eclipse of an incandescent wire by an adjacent cold wire or opaque object, when both are revolving round a common axis, is described. It is shown how the phenomena may be practically applied to the study of the behaviour of a rotating body, by converting such a body into an auto-stroboscope.

In Part II a description is given of the use of an incandescent electric lamp as a colour top and for demonstrating "after-image" effects.

AUTHOR.

**1268.** *Crystelliptometer.* **R. D. Weld.** (Optical Soc. of America, J. 6. pp. 67–91, Jan., 1922.)—A preliminary account of the research here described has previously been given [Abs. 304 (1917)]. The present paper gives a full account of the apparatus finally developed, called a crystelliptometer from its original application to the study of elliptically polarised light reflected from crystals. An outline is given of the mathematical theory of the analysing system, and the paper concludes with data obtained on the properties of selenium crystals with a view to testing the theory of the optical laws of crystals developed by Drude. A. W.

**1269.** *A New Ophthalmoscope.* **J. K. A. W. Salomonson.** (Optical Soc., Trans. 22. 2. pp. 53–61; Disc., 62, 1920–1921.)

**1270.** *Simple Theory of the Nephelometer.* **P. V. Wells.** (Am. Chem. Soc., J. 44. pp. 267–276, Feb., 1922.)—It is shown theoretically and by experiment that the ratio between the depths of two suspensions of equal brightness has the same value whether the measurements are made by diffuse reflection or by transmission. The indiscriminate use of either of these methods of measurement is, however, permissible only over an intermediate range of concentrations. For extremely dilute suspensions, for instance less than $10^{-5}$ gm. per cm.$^3$, the transmissions are quite insensitive, whilst the measurement of the reflection remains sensitive down to the limit of vision; by increasing the incident intensity Rayleigh has been able to measure the light scattered by gaseous molecules. On the other hand, with very turbid suspensions the transmission probably follows less complicated laws. Although masses in suspension far too small to be detected by the most delicate balance may easily be measured in a Tyndall beam, the precision of such a measurement can never exceed that of the most accurate photometry, that is about 0·2 %. For sensitive and rapid work the nephelometric method takes its place with other volumetric methods. The phenomena of diffuse reflection and transmission are highly complicated and involve many secondary effects which cannot be neglected, but the general course of the phenomena may be represented by the simple theory indicated by the author. T. H. P.

**1271.** *Chromatic Emulsions.* **H. N. Holmes** and **D. H. Cameron.** (Am. Chem. Soc., J. 44. pp. 71–74, Jan., 1922.)—Emulsions exhibiting a wide range of structural colours can be prepared by shaking together, in presence of a suitable emulsifying agent, two immiscible liquids which possess the same refractive index but a marked difference in dispersive power. The phenomenon is well shown with glycerine (of refractive index 1·4660) when dispersed in acetone or amyl acetate containing in solution as emulsifying agent 2–4 % of cellulose nitrate, the refractive index of acetone being 1·3588 and that of amyl acetate 1·4017. On adding cautiously benzene (refractive index 1·5014) and shaking until the refractive indices of the two phases become equal, the white opaque emulsion becomes transparent but is accompanied by striking prismatic colours which change with small variations of benzene content and remain stable for several days. The final emulsion may contain over 30 % glycerine.

A similar effect can be obtained by a 2 % solution of rubber in toluene on shaking with water which has been saturated with cane sugar to give it high optical dispersive power and high refractive index. J. N. P.

**1272.** *Interference Phenomena in Non-homogeneous Light.* **N. K. Sethi.** (Indian Assoc. for Cultivation of Science, Proc. 7. Parts 1 and 2. pp. 37–46, 1921.)—(1) In Lloyd's experiment, if a retarding plate of glass immersed in a liquid of nearly equal refractive index is introduced in the path of one of the interfering beams, a very large number of fringes is obtained. The interposition of coloured screens reduces the number of fringes. No band may be described as central, and the width of the fringes, too, is not constant, but varies continually from one end of the field to the other. This is shown to be due to what may be called the dispersion of the achromatic band, which causes different groups of waves in the spectrum to produce max. visibility of the fringes in different parts of the field. (2) Newton had observed that the number of white-light fringes seen in a thin plate is increased considerably by viewing them through a prism. Rayleigh explained this as being due to the formation of an achromatic system of fringes, the necessary condition for which is that the thin plate should be bounded by curved surfaces; and according to him this phenomenon could not be expected in a truly wedge-shaped plate. The author has, however, observed it even in the case of an air film between two interferometer plates, and has shown that an achromatic system of fringes is not needed to explain Newton's observations. The dispersion of white-light fringes referred to above is sufficient to explain not only the increased number of fringes, but also to give a colour distribution corresponding almost exactly with Newton's observations. A. W.

**1273.** *Photo-Sculpture.* **H. M. Edmunds.** (Phot. J. 62. pp. 82–85; Disc., 85–88, Feb., 1922.)—Describes the author's method of producing reliefs by photography. A system of lines, actually a spiral with forty turns to the inch, is projected upon the subject to be reproduced. A photograph is then taken with the camera so placed that its lens has the incident nodal plane coincident with the emergent nodal plane of the lens projecting the line system. The degree of relief depends upon the distance between the camera and projector in relation to the distance between the latter lens and the object. A relief of about one-third has been found most convenient for mechanical reasons. The photograph of the spiral, as it appears when projected on the object, forms a guide plate. The line on this is followed by hand with a microscope cross-wire, and this is linked with a high-speed taper drill in such a manner that the departure of the line from the position it would occupy if the surface had been flat gives the correct depth of cut to the drill. Alabaster has been found to give the best results. J. W. T. W.

**1274.** *Optics; Experiments on Fabry-Perot Rings.* **P. N. Ghosh.** (Indian Assoc. for Cultivation of Science, Proc. 7. Parts 1 and 2. pp. 53–59, 1921.)—This paper gives a description and explanation of a triple set of horizontal rainbows seen on a sooty water surface, and then gives an account of some preliminary experiments on Fabry-Perot rings in three parallel plates of quartz, one cut perpendicular to the optic axis, one parallel to it, and one at 45°. A. W.

**1275.** *Elementary Geometrical Construction for Astigmatic Refraction.* **H. Cranz.** (Zeits. Instrumentenk. 42. pp. 33–45, Feb., 1922.)—Describes a method of obtaining by geometrical construction the position of the image points in astigmatic refraction (*a*) through a plane surface, (*b*) through the principal section of a prism, (*c*) through a spherical surface, (*d*) through a lens or system of lenses. J. W. T. W.

**1276.** *Testing Microscope Objectives.* **Hartridge.** (Cambridge Phil. Soc., Proc. 21. pp. 29–37, Feb., 1922.)—Describes new methods for the testing of microscope objectives in which the lens is examined piece by piece. The rays illuminating the object on the microscope stage are limited to narrow bundles, corresponding to the particular objective aperture to be tested, by means of suitable stops placed in the lower focal plane of a well-corrected condenser system. To avoid diffraction as far as possible, the object chosen is one of a number of fine metal filings mounted between a slide and cover-glass with Canada balsam. The glass plate micrometer is mounted on a separate microscope stand, which is fixed above the microscope in which the objective is being tested, and the alteration in the position of the image pattern produced by changing the part of the aperture under test (this alteration being produced by moving the slit) is compensated by tilting this micrometer plate through a known angle. The plate is calibrated by substituting a ruled glass slide for the test object, and then observing the amount of tilt required, at unit magnification, in order to bring first one and then another of the standard lines on the tilting micrometer into coincidence with a line of the ruled slide. J. W. T. W.

**1277.** *Physical Study of Spherical Aberration.* **L. C. Martin.** (Optical Soc., Trans. 23. 2. pp. 63–92, 1921–1922.)—Part I deals with the theoretical basis of possible methods for numerical computation on Huyghens' principle. Aberration must be expressed in terms of relative phase. Effects at the paraxial focus differ considerably from those at the best visual focus when aberration is present. A short discussion of spherical aberration on the Fresnel zone theory leads to some of the general effects verified in practice.

Part II. Experimental Study. The aberrations of a known microscope objective were computed for varying "tube lengths" and were experimentally checked by the results of a specially devised modification of the Hartmann method. An ultramicroscopic pinhole in a silver film was used as an object. The appearances at and near the focus with differing known aberration residuals were photographed and thus examined for size and light distribution. Visual "extinction" methods were also employed. Curves and photographs illustrate the results. The "spurious disc" appearance is shown to persist near the best visual focus even in the presence of large amounts of aberration. The effect of increasing aberration is to draw light from the central concentration and scatter it in the surrounding field, and, from measurements of the loss, the necessity of restricting the phase residuals to within $\lambda/6$ is inferred. Spherical aberration is found to produce marked asymmetry on each side of the focus, a matter of great importance in some optical instruments.

AUTHOR.

**1278.** *Annealing of Glass.* **Taffin.** (Comptes Rendus, 174. pp. 36–39, Jan. 3, 1922.)—Adams and Williamson [Abs. 1587 (1920)] have proposed the formula $1/\Delta - 1/\Delta_0 = K \cdot t$ for the cooling of glass, $\Delta$ being from 50 to 5 $\mu\mu$/cm.; $\Delta_0$ the double refraction when $t = 0$, and K an exponential function of the temperature $\theta$. The author has repeated the experiments of Adams and Williamson, and sought to generalise their law for retardations between 95 and 5 $\mu\mu$. The double refraction was measured by a method previously described [Abs. 523 (1922)]. The table of results gives the values of $t$ calculated by Adams's formula as a function of $\Delta$ and $\Delta_0$. In proportion as $\Delta_0$ increases, the divergence between the measurements and the calculated values increases. This has led to the introduction of a correction term, giving the formula $1/\Delta - 1/\Delta_0 + A(1/\Delta^2 - 1/\Delta_0^2) = B \cdot t$ . . . (1), where $\log A = a - b\theta$, and $B = c/(\Theta - \theta)$. $a$, $b$, $c$, and $\Theta$ are constants for a given specimen of glass. Another formula obtained was

$$\log\left\{(1/\delta - 1/\Delta_0)/(1/\delta - 1/\Delta)\right\} = t/T \quad \ldots\ldots\ldots \quad (2),$$

where $\delta = C_1 e^{C_2(\Theta - \theta)}$ and $T = k(\Theta - \theta)$; $C_1$, $C_2$, $k$, and $\Theta$ being again constants for a given specimen of glass. Examination of the results shows that for initial strains below 50 $\mu\mu$, Adams's formula and formulæ (1) and (2) represent the results equally well. For strains between 50 and 100 $\mu\mu$ Adams's formula gives values of $t$ below those observed. Formulæ (1) and (2) represent the results in this range about equally well, and further experiments will be necessary to decide which should be adopted.

A. W.

**1279.** *Microscope Test-Plates and Microscopic Definition.* **A. Mallock.** (Nature, 109, pp. 205–206, Feb. 16, 1922.)—Describes results obtained in ruling test-plates of 30,000 to 60,000 lines to the inch in a layer of methyl-violet on glass [see Abs. 1651 (1921)]. The point used was a natural diamond point carried on a very light pendulum structure so that exceedingly small pressures could be used for ruling. The methyl-violet films were less than one-tenth of a wave-length thick, and were satisfactorily opaque. The paper concludes with a discussion of the degree of magnification useful to the average eye, and of the form of a plano-convex lens for the conversion of a divergent pencil into a parallel beam. J. W. T. W.

**1280.** *Light Emission from a Moving Source in Connection with the Relativity Theory.* **N. Rashevsky.** (Phys. Rev. 18. pp. 369–376, Nov., 1921.)—*Light Emission from a Moving Source; a Generalised Explanation of the Michelson-Morley Experiment.*—The paper is based upon unpublished work left by the late N. Pashsky, of Kiev. It is pointed out that the experiment does not prove the constancy of the velocity of light, but merely that if light is sent out in all directions from the centre of a spherical mirror, all rays after reflection will return simultaneously to the centre no matter what the velocity of the system through space. This result requires merely that with respect to axes moving with the source the velocity of light in a direction making an angle $\phi$ with the direction of motion is given by $\sigma_\phi = \sigma/\left\{1 + \sqrt{[\psi \cos \phi/(\sigma + \psi)]}\right\}$, when $\sigma$ and $\psi$ are arbitrary functions of the velocity of translation $v$, with the only conditions that for $v = 0$, $\psi = 0$, and $\sigma = c$. There are therefore an *infinite number of possible hypotheses* which will explain the experiment, *in addition to the relativity theory*, which assumes that $\sigma_\phi =$ constant. The only way to decide the matter would be to measure the velocity of light by a method in which the ray of light would not return to its starting-point. AUTHOR.

**1281.** *Flow of Energy near an Optical Focus.* **T. K. Chinmayanandam.** (Indian Assoc. for Cultivation of Science, Proc. 7. Parts 1 and 2. pp. 21–28, 1921.)—Mathematical.

**1282.** *Propagation of Light in Rotating Systems.* **L. Silberstein.** (Eastman Kodak Co. Research Lab., Comm. No. 123. Optical Soc. of America, J. 5. pp. 291–307, July, 1921.)—A general discussion not admitting of a brief abstract. L. H. W.

**1283.** *On the Thin Astigmatic Lens.* **T. Chaundy.** (Optical Soc., Trans. 23. 1. pp. 56–58, 1921–1922.)—For the normal refraction of an aspherical wave-front at an aspherical surface three quantities are introduced which obey the Gaussian formula of symmetrical normal refraction. AUTHOR.

**1284.** *An Unfamiliar Anomaly of Vision; Relation to Optical Instruments.* **W. B. Rayton.** (Optical Soc. of America, J. 5. pp. 323–327, July, 1921.)—The effect discussed is the inclination towards one another of two parallel lines when viewed through a telescope provided with a prism erecting system. L. H. W.

**1285.** *Tracing Caustic Curves.* **A. S. Percival.** (Phil. Mag. 43. pp. 258–277, Feb., 1922.)—Mathematical; plano and bispherical lenses are considered. L. H. W.

**1286.** *Pathological Effects of Radiation on the Eye.* **F. H. Verhoeff** and **L. Bell.** (Am. Illum. Eng. Soc., Trans. 16. pp. 625–664; Disc., 664–665, Dec., 1921.)—The authors summarise the results of a comprehensive series of experiments on the effect of radiation on the eye, confirmed by tests carried out on the eyes of animals. Amongst the most important conclusions may be mentioned: The liminal exposure capable of producing photophthamia is $2 \times 10^6$ ergs per cm.$^2$ of abiotic radiation (such as is derived, for example, from the magnetite arc). The inverse square law was verified for a range of 156 : 1. Within 24 hours energy effects are simply additive. The period of latency varies according to severity of exposure, but for subliminal exposures is roughly 24 hours. Abiotic action on living tissues is confined to wave-lengths shorter than 305 $\mu\mu$. Even with very severe exposures the lens substance is affected to a depth less than 20 $\mu$, and in the rabbit this superficial effect undergoes complete repair. Effects of abiotic radiation are distinct from those produced by heat. The retina may be flooded for an hour or more with light of extreme intensity (not less than 50,000 lux) without any permanent injury, and to injure the cornea, iris, or lens by thermic effects of radiation requires a concentration of energy obtainable only under extreme experimental conditions. No concentration of radiation on the retina from any artificial illuminant is sufficient to produce injury under practical conditions. Eclipse blindness is due to concentration of heat, almost wholly due to visible rays. Erythropsia, vernal catarrh, and senile cataract are not due to radiation; glassblowers' cataract is due not to abiotic action, but probably to general overheating of the eye. Commercial illuminants are free from danger under ordinary conditions of use, when no protective glasses are needed. For protection against abiotic action in experiments or in snowfields, ordinary coloured glasses suffice. J. S. D.

**1287.** *The Goldberg Wedge.* **F. C. Toy.** (British Phot. Research Assoc. Lab., Comm. No. 17. Phot. J. 62. pp. 110–111; Disc., 111, Feb., 1922.)—It has been noticed that when an exposure is made through a Goldberg wedge on to a photographic plate, interference fringes are formed on the latter if the light is monochromatic. These fringes are sometimes very strong, and are a nuisance in many cases where monochromatic light is employed. In the illustration given it can be seen that there are two distinct sets of fringes, one much stronger than the other. Experiments have been carried out to determine where these fringes are formed, and it has been found possible to eliminate them completely. The stronger set of fringes is formed between the inside surface of the cover glass and the upper surface of the gelatine layer containing the carbon. These surfaces are really only in contact at a few points; at other points they are just a few wave-lengths of light apart, the ideal conditions for the formation of strong interference fringes. This fault can be completely removed if the cover glass is separated from the gelatine layer by a small distance, say about 0·3 to 0·5 mm. The thickness of a stout paper is quite sufficient. This should be inserted in the form of a narrow strip underneath the edges of the cover glass during the construction of the wedge. The faint fringes are formed in the space between the surface of the sensitive layer of the photographic plate and the back of the glass base of the wedge. These can also be eliminated if the plate is prevented from making contact with the wedge base, a distance of 0·25 mm. being quite sufficient in this case. An error is introduced by moving the sensitive film farther away from the wedge, but it is exceedingly small, and is negligible compared with the error which exists when the fringes are present. A. E. G.

**1288.** *Wave-lengths in the Extreme Ultra-Violet.* **H. Buisson and C. Fabry.** (J. de Physique et le Radium, 2, pp. 297–303, Oct., 1921.)—The authors refer to a previous paper [see Abs. 76 (1922)] for a description of their double spectroscope, and now give some corrections to figures included in the tables of that paper. The present paper describes the method adopted, of regulating the exposure of successive portions of the spectrum to obtain uniform darkening of the film, irrespective of the relative intensity, and the use of other forms of instrument to obtain check comparison photographs. The region now tabulated extends from 2898·4 Å. to 3050·82 Å. The authors consider that for wave-lengths greater than this, Higgs's spectrographs, with reseau, are not only much easier to measure, but have better definition. The wave-lengths given are obtained by interpolation from those of the numerous Fe lines. The accuracy claimed is between 2 and 3 tenths of an angstrom for the shorter wave-lengths and one-tenth Å. for the longer ones. For indentification, Kayser's tables, which appear to include the determinations of Exner and Haschek, are used, and most of the lines are identified with certainty. Lines too close to be separated are bracketed. Some few anomalies in intensity of lines are noted. Among the elements represented with certainty are Ni, Mn, Co, Mg, Si, C, Sr, Ge, Ca, V, Ru, Mo, Sn, Y, Ga, Er, Ta, and possibly Na and K. W. W. B.

**1289.** *Effect of the Pressure of Gases on the D-Lines in Saturated Sodium Vapour.* **R. Minkowski.** (Phys. Zeits. 23. pp. 69–73, Feb. 1, 1922.)—The apparatus and method employed were the same as were used in previous work [see Abs. 877 (1922)]. The greatest pressure of nitrogen used was 50 mm. of mercury at room temperature, corresponding to about 100 mm. of mercury at the temperature used. At higher pressures the D-lines were much broadened. The results obtained show a reduction of intensity of both D-lines as the nitrogen pressure is increased, but the decrease in intensity is the same for both, and consequently the intensity ratio is unaltered. It appears probable from this that the number of dispersion electrons per cm.$^3$ is dependent on the pressure. [See Abs. 1985 and 1986 (1921).] A. W.

**1290.** *Infra-Red Absorption Spectra of Alkali Hydroxides.* **G. E. Grantham.** (Phys. Rev. 18. pp. 339–349, Nov., 1921.)—The absorption of various concentrations of solutions of NaOH, KOH and LiOH, and of one solution each of $NH_4OH$ and CsOH, was determined with reference to that of water. All curves show a broad, intense absorption band with a maximum at about 2·29 μ except in the case of the $NH_4OH$ solution, for which the maximum is at 2·20 μ. This agreement suggests that the band is due to dissociated hydroxide ions; yet in the case of other hydroxide solutions previous observers have not obtained an absorption band at this place.

*The coefficient of absorption of water,* 1·3 *to* 2·0 μ *was measured* by comparing the transmissions of cells of different thicknesses. Maximum absorption was observed at 1·48 and 1·98 μ. *The effect of dissolving an alkali hydroxide* is to decrease the absorption of the water in the band at 1·48 μ by an amount proportional to the concentration of the solution and to the atomic weight of the base. L. H. W.

**1291.** *New Series of Spectrum Lines.* **F. S. Brackett.** (Nature, 109. p. 209, Feb. 16, 1922.)—With a long hydrogen tube, viewed end-on, as a source, lines have been observed at 4·0(5) μ and 2·6(3) μ, which, according to Bohr's theory, may be explained as due to an electron falling from the fifth to the fourth and from the sixth to the fourth rings respectively, forming the first two members of a new series. Lines have been observed at 1·8(8) μ, 1·2(8) μ, 1·0(9) μ, 1·0(1) μ, and 0·9(5) μ. These form the first five members of the Paschen series due to an electron falling into the third ring from the fourth, fifth, sixth, seventh, and eighth rings respectively. The first two of these were observed and accurately measured by Paschen. The first line of the new series is approximately one-fourth the intensity of $H_a$; the first Paschen line is more intense than $H_a$, the intensity ratio being 4 : 3. A. W.

**1292.** *Significance of the ½ Terms in Spectral Series Formulæ.* **P. D. Foote** and **F. L. Mohler.** (Optical Soc. of America, J. 6. pp. 54–56, Jan., 1922.)—Sommerfeld concluded that the ratio of the constant $a^*$ for the enhanced spectrum of an alkali earth, to the constant $a$ for the arc spectrum of the alkali of next lower atomic number should be $a^*/a = 2$. Actually the average deviation from this value is + 32 %. If, however, with the same number of electrons in a ring, the charge on the nucleus be increased, the diameter of the ring decreases. Taking this into account, for 50 electrons in a ring $a^*/a = 1\cdot 8$. A table is calculated to show the value of this ratio, in the case of two rings and the effect of the nuclear charge on the radii of the rings being taken into consideration. The average deviation from the observed values is thus found to be 4 %, so that it is concluded that to $m$ integral values should be assigned for the $ms$ and $m\sigma$ terms, as is the case with the $mp$, $md$, and $mb$ terms, and the half integral values of $m$ in the $ms$ terms have no special significance. J. W. T. W.

**1293.** *Excitation Stages in Open Arc-light Spectra.* II. *Silver, Bismuth, Cadmium, Zinc, Air, and Copper.* **B. E. Moore.** (Astrophys. J. 54. pp. 246–272, Nov., 1921.)—By a study of the *variation of the spectrum with current* for from 0·02 to 1 amp., about 90 *lines have been classified* in one or other of the five stages described in Part I. All lines appear first at the negative pole, then at the positive, and later still in the middle of the arc. Lines of Stage I come in first, usually resonance lines, the first terms of principal series. As the current is increased, the arc suddenly flares up and the lines of Stage II appear, the lowest ionisation lines, including diffuse subordinate series and terms of the principal series. Lines of higher stages are distinguished chiefly by their inception currents, which are often three times greater for one stage than for the preceding stage; whether they are due to successive ionisation is unknown. When lines first come in, they are often intermittent and in any case have an appreciable and sometimes a considerable intensity. Before the lines of Stage I appear, the glow shows a continuous spectrum and also bands, probably due to molecules, elementary or compound. In fact, most bands require only low excitation, some ceasing with Stage I; but others develop like Stage II lines. *Intensity–current curves for* 18 *lines* are given. They vary considerably in form, including three different types. Intensity growth of the positive pole is similar to that at the negative, as a rule, but later. *The relation of these results to the Bohr theory and to the Ritz* *equations* is briefly discussed. When the ring positions corresponding to the types of spectral lines are represented graphically, it appears that lines of a given stage are associated with rings lying within certain limits and that both these limits are larger in radius the later the stage; but the ranges for the various stages overlap. In a *discussion of Fowler's classes of enhanced lines*, it is pointed out that classification by excitation stages permits a more precise definition of enhancement, since the lines of each stage are evidently enhanced with reference to those of all earlier stages. A *comparison with King's temperature classification* in the case of Cu lines shows no correlation, some of his Class III lines falling in each excitation stage from I to IV.

*Arc Spectrum of Cadmium.—A new resonance line* at λ3779 belonging to Stage I was discovered. Hitherto it had probably been supposed to be an iron line.

*Arc Spectrum of Air.—With low excitation two new lines* appear at λ3064 and λ3068, which may belong to the positive nitrogen bands.

AUTHOR.

**1294.** *Intensity and Broadening of Spectral Lines.* **C. Füchtbauer** and **G. Joos.** (Phys. Zeits. 23. pp. 73–79; Disc., 79–80, Feb. 1, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The research dealt with in this paper is concerned with the broadening by foreign gases of the mercury line λ2537, which is absorbed by the unexcited vapour. The pressure range covered was from 10 to 50 atmos. The form of the absorption curve was investigated, and it was found that the characteristic form was dependent much more on the disturbing gas than on the disturbed atoms. An atmosphere of $CO_2$ or nitrogen was found to give unsymmetrical broadening of the line λ2537. With hydrogen, on the other hand, the broadening was almost symmetrical. The half-value width of λ2537 was found to be strictly proportional to the density of the nitrogen throughout the pressure range of 10 to 50 atmos. With the same number of atoms per $cm.^3$ hydrogen was found to give a considerably greater broadening than nitrogen, and in this case also the broadening was proportional to the density. The total absorption was found to decrease slightly with increased broadening for equal numbers of atoms. For the first pair of the principal series of cæsium (both lines of the doublet taken together) the number of dispersion electrons calculated from theory is equal to the number of Cs atoms. For the Hg line λ2537, however, the number of resonators is about 45 times smaller than the number of atoms. Experiments on the shift of the maximum of λ2537 showed that the shift towards the red was less in the case of hydrogen than for $CO_2$ and nitrogen.

A. W.

**1295.** *Occurrence of "Enhanced" Lines in the Arc.* I. **G. A. Hemsalech** and **A. de Gramont.** (Phil. Mag. 43. pp. 287–306, Feb., 1922.)—A convenient method was found for obtaining the arc spectra of volatile metals. A piece of the metal is laid on a copper plate about 5 cm. × 10 cm. and not less than 1 mm. thick. This plate is fixed and is connected to the positive terminal of the supply. A pointed carbon rod, which can be raised or lowered, is placed vertically above the piece of metal. As soon as the arc is struck, the metal melts and forms a globular mass, from which the arc continues to burn steadily. The copper plate serves to dissipate heat, and thus prevents the rapid boiling away of the metal.

With this arrangement continuous arcs have been obtained with Sb, Bi, Mn, Na, Sn, Cd, Zn, Pb, Tl, Al, Mg, and Li. Experiments are described which seem to indicate that spark lines are brought out in the arc when the degree of ionisation is lowered, as, for example, by blowing air through the arc. The effect of various liquid media on the character of the arc spectrum of a metal was investigated by placing a drop of the liquid between the poles before striking the arc. The spark lines, or so-called high-temperature lines, disappear from the arc when the kathode is formed by white-hot carbon. They are brought out prominently, on the other hand, when the electrodes are cooled down to about − 190° C. by immersion in liquid air. A detailed account is given of the results of observations on the relative behaviour of different types of lead and tin lines in the arc under various discharge conditions. It appears from the results of the experiments that: (1) The presence of hydrogen is not essential for the excitation of spark lines. (2) Spark lines attain a high degree of development only in a medium which offers a comparatively high electrical resistance. (3) When hydrogen is present in the medium, either in the free state or in combination, its spectrum resembles that which is only observed with high-tension condenser discharges, its lines being symmetrically broadened as though under the influence of a strong electric field (Stark-effect). A. W.

**1296.** *Series in the Resonance Spectrum of Iodine.* **R. Mecke.** (Zeits. f. Physik, 7. 2. pp. 73–85, 1921.)—The resonance spectrum of iodine investigated by Wood [Abs. 801 (1913)] consists of a series of doublets of the band type, which can be represented (within the experimental errors) by the series formula $\nu = A + Bm + Cm^2 + Dm^3$. In this formula A is given by the exciting line, while C and D remain the same for all exciting lines. The second member is variable, and when put into the form $B = b_0 - b_1 n$ (where $n$ is a whole number) it appears that a number of partial series may exist. Investigation of the resonance spectrum excited by the green mercury line showed that eight such doublet series could be identified, and that these could be arranged in two groups according to the position of the doublet components. In one of these groups $b_1$ has the value 0·655, while in the other group $b_1 = 0{\cdot}75$, $n$ taking the values 0, 1, 2, and 3. Further regularities within the series are probable, but cannot yet be stated with certainty. Theoretical considerations appear to show that $m$ represents an azimuthal quantum number. But since, on account of the smallness of the moment of inertia, the rotation cannot be assigned to the molecule itself, it is assumed that the moment of inertia is possessed by a rotating electron ring. From this the series formula can be deduced. It is further shown that resonance spectra are due to electron transfers, as with line spectra. A. W.

**1297.** *Stokes' Law and the Fluorescence of Iodine Vapour.* **P. Pringsheim.** (Zeits. f. Physik, 7. 3. pp. 206–216, 1921.)—Investigation of the resonance spectrum of iodine vapour excited by the green mercury line showed that by raising the temperature of the vapour from room temperature up to 320° C., the intensity of the lines (of negative term number) not following Stokes' law was increased many times. At the same time the intensity of some of the lines of positive term number was somewhat greater, while the majority were reduced in intensity. It is thought that these resonance lines exhibiting such opposed characteristics belong

to different series which owe their origin to different iodine absorption lines covered by the green mercury line. [See Abs. 1228 (1906.)]
A. W.

**1298.** *Evolution of Magnesium Spectrum under the Influence of Electric Fields.* **A. de Gramont and G. A. Hemsalech.** (Comptes Rendus, 174. pp. 356–361, Feb. 6, 1922.)—The changes which take place in the character and intensity of the lines of the Mg spectrum as the intensity of the electric field applied to the light source is varied from zero to a high value, have been studied in detail, and the results are presented here in tabular form and discussed.

*Application to Astrophysics.*—The research shows that the spectral effects of intense electric fields are especially noticeable in the initial stage of a luminous source (arc or spark) when the temperature and the electric conductivity of the vapours are still low. In proportion as the temperature increases, the emission which depends on the presence of rapid fall of potential diminishes, or even disappears. It is, in consequence, not justifiable to conclude that a star possesses a high temperature because spark lines predominate in its spectrum; and such a conclusion would be particularly difficult to uphold in the case of the development of a new star. It would appear that the term "high-temperature stars" should be replaced by the term "stars with powerful electric discharges," since the lines exhibited by so-called very hot stars are produced by electric discharges with large differences of potential [see Abs. 130 (1922)]. A. W.

**1299.** *Standard Wave-lengths.* 1920 *Report of Committee of Standard Wave-lengths.* **W. F. Meggers.** (Optical Soc. of America, J. 5. pp. 308–322, July, 1921.)—A summary of past activities as an introduction to the present status and tendency of standard wave-lengths. L. H. W.

**1300.** *Discovery of the Zeeman-Effect.* **O. J. Lodge.** (Electrician, 88. pp. 182–186, Feb. 17, 1922.)—These two papers by the author, which appeared in the *Electrician* in 1897, are here reprinted with his present-day annotations, together with a letter from Zeeman referring to the author's review of a reprint of his own papers on magneto-optics—a present from his Dutch friends commemorating the twenty-fifth anniversary of his discovery. In this letter it is suggested to the author that a reprint of early articles on the subject, as they appeared in the *Electrician*, would be interesting to the younger generation of physicists. Zeeman also makes the following very suggestive observation:—"It is rather remarkable that the new theory of quanta is still at a loss to understand some of the complicated, extremely regular, magnetic separations, such as the nonet of the green mercury line, or the cadmium line 5086. In the *Zeitschrift für Physik*, recently, important papers on the subject, by Landé, have appeared, but there is still something wanting." Of the author's present-day notes two may be specially noted:—Note K, in which he points out that "the electrical explanation of inertia is not an ultimate explanation, but postulates an unknown property, akin to tremendous massiveness—a property responsible for all observed atomic inertia—as existing unexplained in the continuity of the ether of space." Note D, in which he urges students and teachers not to sacrifice the beauty and simplicity of really absolute measure, *e.g.*, by omitting the factor $\mu$ from magnetic expressions. G. W. DE T.

**1301.** *Dependence of Intensity of Fluorescence of Dyes upon the Wave-length of the Exciting Light.* **S. I. Vavilov.** (Phil. Mag. 43. pp. 307–320, Feb., 1922.)—The connection between the energy of exciting light and the intensity of fluorescence can be expressed on the ground of a precisely established experimental law as $\int_0^\infty f_{\lambda f} . d_{\lambda f} = F = k . I_\lambda . \alpha_\lambda . \Delta\lambda$, where $\lambda_f$ is the energy of fluorescence corresponding to the interval of wave-length of fluorescence $d\lambda_f$, F the integral energy of fluorescence, $I_\lambda$ the energy of exciting light, $\alpha_\lambda$ the part of the light absorbed by the fluorescent dye in a finite small interval $\Delta\lambda$. The value of $k$, which gives the energy of fluorescence per unit of absorbed energy, and is termed the specific fluorescence, is generally a complicated function of $\lambda$. The first stage of the problem which arises here is the dependence of $k$ upon $\lambda$ within an isolated absorption-band. An attempt at an experimental solution of this problem by Nichols and Merritt showed that the specific fluorescence of eosin and resorufin increases towards long wave-lengths, for resorufin by 2·7 times (at the change of wave-length of exciting light from 520 $\mu\mu$ to 600 $\mu\mu$), and by 1·63 times for eosin (480 $\mu\mu$ to 560 $\mu\mu$). These authors have stated a generalisation of these results [see Abs. 856 (1915)] without giving a theoretical explanation. The scope of the present paper is to find experimentally how general is the result of Nichols and Merritt that the specific fluorescence of resorufin and eosin increases towards long wave-lengths. Experiments, with details, are described. The distribution of energy was investigated, and a set of dyes chosen whose absorption bands covered the whole region accessible to visual investigation from 400 $\mu\mu$ to 600 $\mu\mu$. Tables and curves of results are included. Within the limits of errors of observation the specific fluorescence of the dyes investigated is independent of $\lambda$ within their band of absorption, and the result is equivalent to the conclusion that the curves of absorption are physically simple ones. Einstein's theory of the simplest photochemical reactions leads to the result that the coefficient of the velocity of reaction must be inversely proportional to the frequency of the active light, but the conclusion applied to fluorescence is not confirmed. The deviations required by this theory are so small that they exceed by only a little the experimental errors, and the author is unable to make a definite statement. The intensity of fluorescence radiated by a definite molecular resonator depends only upon the value of the absorbed energy, and upon the mechanism of the resonator. Therefore in the case of an excitation by a white light $F = k\int_{\lambda_1}^{\lambda_2} I_\lambda . xc . e^{-xcd} . d\lambda$. The result of Nichols and Merritt shows probably only the physical complexity of the bands of the dyes studied by these authors. H. H. Ho.

**1302.** *Blue Glow of Luminescent Oxides at Low Temperatures of Incandescence.* **E. L. Nichols** and **H. L. Howes.** (Optical Soc. of America, J. 6. pp. 42–53, Jan., 1922.)—Certain oxides when heated to incandescence emit a blue light at temperatures corresponding to a dull red heat of non-selective radiators. The paper describes experiments in which the emission from a layer of the oxides of Mg, Be, Ca, Al, Si, Z, and Ce, heated with an oxy-hydrogen flame, was compared with that from black uranium oxide at temperatures from 665° to 1600° C. The emissions were compared (*a*) through a red glass of effective wave-length

$0 \cdot 65\ \mu$, and (*b*) through ammonio-sulphate of copper having an effective wave-length of $0 \cdot 45\ \mu$. The ratio of the emissions at the shorter wave-length was found to be highest at the lower limit of temperature, and to decrease gradually with increase of temperature until in many cases it became less than unity. The curves of $I_{\text{oxide}}/I_{\text{black body}}$ were found to be similar in shape for all the oxides, those for five oxides being shown in the Fig. In general it is concluded that as the temperature rises the ratio $I_0/I_{bb}$ falls, since the rise of $I_0$ is much slower than that of $I_{bb}$, until at about 1000° C. the temperature radiation supplants the luminescence and the effect of further increase in temperature is then that expressed by the usual equation for black-body radiation.

The blue glow phenomenon is found in bodies which have the following characteristics (in addition to refractoriness): (*a*) they are inactive under light or X-rays; (*b*) they show luminescence in the kathode tube; (*c*) in many cases they are sensitive to flame excitation; (*d*) they are white. The luminiscence is subject to fatigue, and is affected by heat treatment, being often destroyed by fusion of the oxide. It is dependent on the mode of heating, being much more intense when excess of oxygen is present. The phenomenon appears to be one of instability associated with and perhaps dependent upon changes of the conditions of equilibrium. Thus all the oxides which exhibit the blue glow are in transition, within the temperature range in question from a condition of almost infinite electric resistance to one of semi-metallic conductivity, and this change is accompanied by the well-known profound modifications in optical properties, radiating power, etc. Again, the outburst of luminescence in silica at 1400° occurs at the transformation point of quartz, and is presumably intimately related to that change. It appears that this form of luminiscence is the result of oxidation. It would appear that a partial reduction takes place through the agency of the hydrogen of the flame, and that this is immediately followed by oxidation, the two opposing processes going on in rapid alternation. J. W. T. W.

**1303.** *Action of Red and Infra-Red Rays on Phosphorescent Sulphides.* **Curie.** (Comptes Rendus, 174. pp. 550–553, Feb. 20, 1922.)—Reference is made to the various theories which have been advanced to explain the extinguishing action of the least refractive part of the spectrum on certain phosphorescent substances, and the view is expressed that the phenomenon is due to the fact that the extinguishing rays render the medium conducting by detaching electrons from the sulphur atoms.

The increase in the conductivity of sulphur under the influence of light was noticed by Bates (*Le Radium*, 1911), and it is now found that such increase is very great if the total radiation from a tungsten-nitrogen lamp is used; if, however, a red screen is interposed, the increase is considerably diminished, although still distinct. With zinc sulphide kept for some days previously in the dark and showing no fluorescence, red light causes a far greater increase in conductivity than with sulphur, the electrons being detached from the sulphur atoms of zinc sulphide more readily than from those of pure sulphur. T. H. P.

**1304.** *Absorption of Fluorescing Sodium Vapour.* **J. K. Robertson.** (Nature, 109. p. 43, Jan. 12, 1922.)—Experiments were carried out with the object of ascertaining whether fluorescing sodium vapour absorbs the lines of the first and second subordinate series, as suggested by Foote and Meggers [Abs. 1174 (1920)]. Sodium was distilled into a tube A 25 cm. long. Immediately below A was placed a sodium-potassium alloy lamp B of about the same length. Both tubes were enclosed in an electric oven, by which the temperature could be raised to 300° C. or higher. Light from a Nernst lamp traversed the tube A and was focused on the slit of a spectroscope. The light from the vapour lamp consists almost entirely of D-lines of narrow width. Experiments at temperatures ranging from 200° to 300° C. showed no difference in the absorption spectrum when the lamp B was "on" or "off." The D absorption lines were easily visible, but not the slightest difference could be detected in the two cases. With improved apparatus a difference might be detected. The lines most likely to be absorbed are the first members, which lie in the infra-red, and so could not be observed visually. The light given by the vapour lamp, again, may not have been sufficiently intense. An arrangement, such as that used for mercury by Füchtbauer [Abs. 446 (1921)], with a considerable increase in length, might enable the sought-for absorption to be observed. [See Abs. 299 (1906).] A. W.

**1305.** *X-Rays and Thermodynamic Equilibrium.* **L. de Broglie.** (J. de Physique et le Radium, 3. pp. 33–45, Feb., 1922.)—A theoretical paper dealing mainly with the laws of absorption of X-rays (critical absorption frequencies) and their relation to the thermodynamics of radiation. A concise abstract is not possible. A. B. W.

**1306.** *Absorption of Narrow X-Ray Beams.* **P. W. Burbidge.** (Phil. Mag. 43. pp. 389–392, Feb., 1922.)—The experiments described were made with the object of ascertaining whether at very small angles there was any large scattering effect of X-rays which may have escaped previous observation. The principle of the method employed is that used by Rutherford and Nuttall [Abs. 252 (1914)] in determining the scattering of α-rays, i.e. the absorption of the rays in some medium is measured (1) with a wide-angle beam, and (2) with a very narrow beam. The comparison between various X-ray beams was made in two stages, the absorption of the wide beam being compared with that of a 4-mm. beam, and this latter with a 0·6-mm. beam. The results are included in the table below.

| Slit. | Plane Angle of Beam of X-Rays. | Mean, μ. | $\mu/\rho$. ($\rho = 0{\cdot}00288$). |
|---|---|---|---|
| Wide .......... | 13° | 0·0072 | 2·50 |
| 4 mm. ........ | 0·5° | 0·0077 | 2·69 |
| 0·6 mm. ....... | 0·07° | 0·0078 | 2·71 |

A. B. W.

**1307.** *Width of X-Ray Spectrum Lines.* **A. H. Compton.** (Phys. Rev. 19. pp. 68–72, Jan., 1922.)—(1) *Four causes* are discussed: (*a*) the width of the slit employed, (*b*) angular imperfections of the crystal, (*c*) finite resolving power of the crystal grating, and (*d*) lack of homogeneity of the X-rays. The effect of the first two causes is independent of the angle of reflection, and therefore the same for all orders and all lines; the effect of the third is shown to vary as $1/\sin\theta\cos\theta$, and therefore to decrease as $\theta$ increases up to 45°; while the effect of the last is equal to $(d\lambda/\lambda)\tan\theta$ and therefore increases with $\theta$. (2) *Measurements of two tungsten lines*, λ1·242 and 1·279 Å. in the first four orders from the cleavage faces of calcite and rocksalt are given. The fact that in both cases the width is least for the second order and greatest for the fourth order shows that both the third and fourth causes contribute measurably to the observed width, as well as the first two.

*Lack of homogeneity of tungsten X-ray lines* computed from the above measurements comes out greater than $0{\cdot}0007\ \lambda \pm 0{\cdot}00013\ \lambda$, which is about 0·5′ for the first order. This cannot be explained as a Doppler-effect or as due to the damping of the electronic motion; however, it is in accord with the complexity of the lines as predicted by Sommerfeld's theory of elliptical electronic orbits. AUTHOR.

**1308.** *Effect of Damping on the Width of X-Ray Spectrum Lines.* **G. E. M. Jauncey.** (Phys. Rev. 19. pp. 64–67, Jan., 1922.)—(1) Assuming exponential damping, the equation for the ether vibrations, $y = e^{-kt}\sin(pt + A)$, is developed as a Fourier integral, and thus a *theoretical relation of the width to the damping factor* is found. If we define the width of the line as the range in wave-length throughout which the intensity is greater than half the maximum intensity of the line, then $x\lambda/\lambda = dp/p = 2k/p$, very closely. (2) *Theoretical variation with wave-length.*—Assuming in addition that $k$ has the value given by the classical theory of a single radiating electron, $d\lambda = 2k\lambda/p = 4\pi e^2/3mc^2 = 1{\cdot}2 \times 10^{-4}$ Å., i.e. $d\lambda$ is independent of wave-length. (3) *Comparison with observation.*—A. H. Compton [preceding Abs.] has found the widths of the W lines, λλ1·242 and 1·279 Å., to be about $9 \times 10^{-4}$ Å., nearly eight times the above value. The discrepancy indicates that either the theory is incorrect, or the measurement is wrong, or that damping is not the chief cause of the observed width. AUTHOR.

**1309.** *X-Rays from Boron and Carbon.* **A. L. Hughes.** (Phil. Mag. 43. pp. 145–161, Jan. 1, 1922. Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 1–6, 1921.)—The photoelectric effect of the radiation from carbon and boron bombarded by electrons has been measured as a function of the energy of the electrons. Two slight but definite breaks in the curves for both carbon and boron were obtained. These are considered to correspond to the K- and L-absorption wave-lengths. The breaks occur at 215 volts (λ57·5) and 34·5 volts (λ358) for carbon, and at 148 volts (λ83·5) and 24·5 volts (λ505) for boron. The L point for carbon is in good agreement with the values measured recently by Millikan for the L emission-lines of carbon vapour. The K points for carbon and boron are approximately where they would be expected on extrapolating the known values of the Ka critical absorption wave-lengths for elements heavier than magnesium. AUTHOR.

**1310.** *An Absolute Scale of X-Ray Wave-lengths.* **O. B. Overn.** (Phys. Rev. 18. pp. 350–355, Nov., 1921.)—In a previous study of the continuous spectrum from a tungsten target, an absorption line was observed at $0{\cdot}7928 \times 10^{-8}$ cm. This result has been confirmed with a Mo target, light lines being obtained at 0·7926 and $0{\cdot}4288 \times 10^{-8}$ cm. To get these lines with a rocksalt crystal a thickness of less than $10^{-8}$ cm. was necessary. *In explanation of the discontinuities* it was suggested by Hull that when any wave-length is reflected by two sets of crystal planes, the energy is divided so that the intensity of the part which reaches the photographic plate is less than for wave-lengths on either side. For each pair of sets of planes the critical wave-length is fixed by the geometry of the crystal alone. Taking the grating constant for rocksalt as $2\cdot814 \times 10^{-8}$ cm., the wave-lengths computed for the planes 100/210 and 100/310 are $0\cdot7959$ and $0\cdot4316 \times 10^{-8}$ cm. respectively. Using these as *reference points*, the centre of the scale of wave-lengths may be accurately determined and a scale of wave-lengths may be established independent of everything except the grating constant.

*Bromine and silver X-ray absorption limits* come near the above reference points, and were thus *accurately located* at $0\cdot9186$ and $0\cdot4842 \times 10^{-8}$ cm., in close agreement with the values given by Blake and Duane.

*K-Series of Molybdenum.—The wave-lengths* of five lines were determined by reference to $0\cdot7959 \times 10^{-8}$ cm. more accurately than in previous measurements. AUTHOR.

**1311.** *Extension of the X-Ray Spectrum to the Ultra-Violet.* **E. H. Kurth.** (Phy. Rev. 18. pp. 461–476, Dec., 1921.)—*Characteristic X-Radiation Due to Slow Electrons,* 1000 *to* 12 *Volts.*—By using the methods of modern high-vacuum technique, the difficulties experienced by previous investigators have been largely overcome. The radiation was measured in terms of the photoelectric current excited from a Pt dish. The effect was made large by utilising a hot tungsten helix as a source of electrons. The deflections obtained were large and perfectly reproducible. When the deflections *per unit* thermionic current were plotted as a function of the accelerating potential, sharp breaks appeared which each indicate the minimum energy necessary to excite the corresponding characteristic radiation. From these energy determinations the corresponding wave-lengths were computed using the quantum relation. Thus the following values have been obtained for the *convergence wave-lengths* in angstroms; *K-series of carbon* 42·6, *oxygen* 23·8; *L-series of carbon* 375, *oxygen* 248, *aluminium* 100, *silicon* 82·5, *titanium* 24·5, *iron* 16·3, *copper* 12·3; *M-series of aluminium* 326, *titanium* 85·3, *iron* 54·3, *copper* 41·6; *N-series of iron* 247, *copper* 116. The relation of these results to those obtained by crystal analysis and by spectrum analysis is discussed. It is suggested that the radiation from solid targets may differ from the radiation from gaseous atoms, especially for the lighter elements. AUTHOR.

**1312.** *Classification of O- and P-Centres by Means of the "Selection Principle" for X-Ray Spectra.* **G. Wentzel.** (Zeits. f. Physik, 8. 1. pp. 85–88, 1921.)—In a previous paper the author has described a method of classification of the "Niveau" (centre) and "Line" scheme of X-ray spectra by means of the symmetry properties and the selection principle. By this method the K-, L-, M-, and N-shells were classified in the case of an "empirical" substance. The author now extends the method of classification to the O- and P-centres of this substance. A. B. W.

**1313.** *Spark Lines in X-Ray Spectra.* **G. Wentzel.** (Ann. d. Physik, 66. 7. pp. 437–462, Feb. 24, 1922.)—On the basis of present theories of atomic structure, the author discusses the production of spark lines in optical spectra by multiple ionisation of the inner "shells" of the atom.

From this he infers that similar "spark lines" should be observed in X-ray spectra. A. B. W.

**1314.** *L-Series Spectra of X-Rays.* **D. Coster.** (Comptes Rendus, 174. pp. 378–379, Feb. 6, 1922.)—A comparison of recent experimental observations by the author on L-series spectra, with similar observations by Hjalmar and by Dauvillier. Various point of agreement and divergence are noted. A. B. W.

## RADIO-ACTIVITY.

**1315.** *Variation of "Emanating-Power" with Temperature. A New Secondary Radium-Emanation Standard.* **J. H. L. Johnstone.** (Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 101–109, May, 1921.)—The variation of emanating power with temperature has been determined for certain specimens of carnotite and uraninite. By heating the minerals to a high temperature, the temperature-coefficient of the emanating power is greatly decreased so that for ordinary ranges of laboratory temperature it may be assumed to be negligible.

A *secondary emanation standard* has been suggested which can be easily and simply prepared, which is not subject to appreciable variations under ordinary conditions and which is more convenient to use, particularly in the field, than either the customary standard radium solution or a uranium mineral of known composition. A. B. W.

**1316.** *Spectrum of Radium Emanation.* **R. E. Nyswander, S. C. Lind,** and **R. B. Moore.** (Astrophys. J. 54. pp. 285–292, Nov., 1921.)—*Spectrum of RaEm, λλ3982 to 7450.*—Two capillary discharge tubes were filled with 0·2 and 1 curie of carefully purified emanation, respectively, and both visual and photographic *measurements* were made with a 4-prism spectrometer. The relative intensities of the lines differed markedly, as a rule, from the previous observations of Watson and Royds, and Rutherford; many strong lines of the 120 previously measured were not found and yet of the 44 lines obtained, 9 are *new lines. Changes of intensity with duration of the discharge* were noticed, some lines decreasing, some increasing in strength, while the colour of the discharge changed from a bright glow to violet. λ5483 and some other *lines flashed out on reversing the current* after a 30-min. run and then quickly disappeared.

*Occlusion of RaEm in Discharge Tube.*—After a discharge had passed through the glass capillary tube containing 0·2 curie for 5 hours, 35 % of the emanation had been occluded, most of it in the Pt mirror surrounding the kathode. The other tube became quite hard after a 4-hour run.

*Modification of Duane's Apparatus for Purifying RaEm.*—The copper wire used to remove oxygen and hydrogen is spirally wound on a silica tube and is heated indirectly by an electrically heated Pt wire passing through the tube, instead of directly by a current through the Cu wire. AUTHORS.

**1317.** *Radium Content of Radio-active Luminous Compounds.* **E. A. Owen** and **W. E. Fage.** (Phys. Soc., Proc. 34. pp. 27–32; Disc., 32. Dec., 1921.)—(1) The absorption of γ-radiation in zinc sulphide has been measured by different methods, and in each case its value was found to be approximately the same. (2) No indication was observed of the occurrence of an abnormal absorption when the radio-active salt was mixed with the sulphide. (3) A table has been compiled giving the values of the ratio of the true to the apparent radium content for tubes of different diameters filled with radio-active luminous compound. This table applies to the case of a compound whose apparent density is 2·03 gm. per cm.$^3$. (4) The values of the absorption of $\gamma$-radiation from radium have been measured in different salts, particular attention being paid to the barium salts with which radium is often found in combination. AUTHORS.

**1318.** *$\gamma$-Ray Action of Extensive Flat Radium Preparations.* **V. F. Hess.** (Phys. Rev. 19. pp. 73–79, Feb., 1922.)—*Intensity of $\gamma$-radiation from a Ra-covered disc at points along the central normal, with and without absorbing layers,* is of interest in connection with the use of radium applicators for $\gamma$-ray treatments. By integrating the effects of narrow rings of the active material, a *theoretical formula is derived* for the intensity at a distance $p$ from a disc of radius $R$ if the rays go through one or more filters whose absorptions are known and through a thickness of tissue $h_0$. This formula involves the so-called exponential integral for which tables are available. Numerical values have been calculated for certain special cases and these are given in two tables which enable the intensity to be determined at various distances from any uncovered disc in air and also from any disc covered by a layer of brass 2 mm. thick. A given amount of radium spread on a 4-cm. disc gives at distances greater than 4 cm. about the same intensity as when concentrated on the end of a small tube, but the effect near the active layer is over ten times less intense in the former case. This result shows that burns of the skin may be avoided by using sufficiently large discs without decreasing the depth action materially.

*A new unit of $\gamma$-ray intensity is proposed,* to be called a *milli-eve* and to be defined as the intensity at a distance of 1 cm. from a point-shaped radium preparation of 2 mgm. AUTHOR.

**1319.** *Peculiarities of Ionisation Tracks.* **J. L. Glasson.** (Cambridge Phil. Soc., Proc. 21. pp. 7–10, Feb., 1922.)—The author refers to reproductions of C. T. R. Wilson's photographs of ionisation tracks of $\beta$-rays through air (see Abs. 1885 (1912)]. Some of these tracks show gradual bending resulting in large deviations. The generally accepted explanation of such deviations is that of multiple scattering, but the author considers that this explanation is insufficient to explain the circular arcs which some of the tracks follow for long distances and the parallelism of adjacent tracks. The theory is advanced that uniform magnetic fields of a temporary nature are responsible for the curvature of the tracks, these fields being conceivably produced by the existence of transient crystalline forms in the gas saturated with water-vapour. A. B. W.

**1320.** *Scattering of $\beta$-Rays.* **J. A. Crowther** and **B. F. J. Schonland.** (Roy. Soc., Proc. 100. pp. 526–550, Feb. 1, 1922.)—The authors describe an investigation of the scattering of $\beta$-rays, which discriminates between the early atomic theory due to J. J. Thomson and the later "nuclear" theory due to Rutherford. To account for certain of the author's earlier observations on the scattering of $\beta$-rays by matter, Thomson's theory required that the observed deflections were due to the cumulative effects of a large number of small deflections. Rutherford's theory, on the other hand, required only a "single" scattering to explain the observations.

The present experiments prove that the single scattering theory most nearly fits the experimental observations, but the latter suggest that any one of our present theories is inadequate to account for the observed scattering of a beam of β-particles in its passage through matter. So far, the investigation has extended only over a small range both of angles and β-ray velocities, and in view of the unexpected nature of the results a much more extensive survey of the subject is contemplated and is now in progress. The authors' method of analysing the experimental data suggests that some change is required in the present "nuclear" theory when the distance between the path of the β-particle and the deflecting particle is less than a certain critical value. A. B. W.

**1321.** *Standardisation of Radium Ampoules for Therapeutic Use.* (Nature, 109. p. 252, Feb. 23, 1922.)—A brief description is given of an apparatus for the routine standardisation of ampoules, containing radium emanation, by the γ-ray ionisation method. This apparatus was recently installed at the Institute Curie. It consists essentially of a screened ionisation chamber connected directly to a gold-leaf electroscope. The ampoule to be tested is placed in an aluminium tray support which can slide along a graduated scale. The intensity of the ionisation current is deduced from the rate of fall of the gold leaf. A novel feature of the apparatus is the method of charging the electroscope by means of a variable multicellular condenser, which obviates the necessity for a high-voltage battery.

A modification of the apparatus is used for measuring the radio-activity of ores, earths, etc. Both instruments were designed by M. Holweck in collaboration with the manufacturer, M. Beaudouin, Paris. A. B. W.

**1322.** *Average Range of β-Rays in Different Metals.* **G. A. Sutherland** and **L. H. Clark.** (Phys. Soc., Proc. 34. pp. 51–53; Disc., 53–54, Feb., 1922.)—A repetition of W. H. Bragg's 1910 measurements has confirmed the early results. L. H. W.

## HEAT.

**1323.** *Production of Liquid Air on a Laboratory Scale.* **J. W. Cook.** (Bureau of Standards, Bull. 17. pp. 277–286 [Sci. Papers, No. 419], 1921.) —A description of the plant, working on the Hampson process at the Bureau of Standards. L. H. W.

**1324.** *A Liquid Oxygen Vaporiser.* **E. A. Griffiths.** (Roy. Soc., Proc. 99. pp. 281–283, July 1, 1921.)

**1325.** *New Specific Heat Apparatus.* **E. Griffiths.** (Phys. Soc., Proc. 33. pp. 355–361, Aug., 1921.)

**1326.** *Thermal Conductivity of Some Wearing Materials.* **E. S. Rood.** (Phys. Rev. 18. pp. 356–361, Nov., 1921.)—Measurements of the conductivity of samples of knitted and woven materials by the disc method of Lees, corrected for variation of emissivity with temperature. L. H. W.

**1327.** *Forced Convection from a Pair of Fine Heated Wires.* **J. S. G. Thomas.** (Phil. Mag. 43. pp. 277–287, Feb., 1922.)—Details some of the characteristics of the forced convection of heat from a fine heated wire due to the passage of a stream of air moving with low velocity and heated by prior passage over a similar wire immersed in the stream. The dependence of this thermal effect upon the distance apart of the wires is, more especially, considered. [See Abs. 970 (1921).] L. H. W.

**1328.** *A Problem in the Theory of Heat Conduction.* **J. W. Nicholson.** (Roy. Soc., Proc. 100. pp. 226–240, Dec. 1, 1921.)—"A long hollow cylinder is immersed in a medium of uniform temperature, and at a certain instant is brought suddenly to a temperature above that of the medium. It is *maintained* at that temperature, and the temperature distribution in the outside medium at any instant, and the rate of leakage of heat from the cylinder, are required." Solutions for the external temperature distribution are apparently known only when the surface has a given *initial* distribution, which is left to adjust itself without further direct supply of heat. With the help of Green's function, a solution is obtained for the temperature $[v_p]_t$ at a point $(x_0, y_0, z_0)$ at time $t$, due to an initial temperature distribution $f(x, y, z)$ at time $t = 0$, and the boundary, S, of the medium being kept at temperature $\phi(x, y, z, t)$ at any subsequent time.

Another problem of more special interest is next attacked, in which a temperature, $v_0$, which is constant, is established at $t = 0$, over a cylindrical surface, $\rho = a$, and *maintained* at the value $v_0$.

Finally the case is taken of a cylindrical surface maintained at any arbitrary law of temperature. An indefinitely long cylindrical surface is maintained from $t = 0$—when everything was at zero temperature—at a temperature F($t$). The temperature at an external point is then found. An indication is thus given of the general solution of problems involving a prescribed temperature variation over a cylinder. This general solution can be made to apply to the internal space by using

Orr's generalisation of the Bessel-Fourier theorem between the limits zero and *a*. The paper is essentially mathematical. T. B.

**1329.** *Form of the Temperature Wave spreading by Conduction from Point and Spherical Sources; Suggested Application to Problem of Spark Ignition.* **E. T. Jones, J. D. Morgan,** and **R. V. Wheeler.** (Phil. Mag. 43. pp. 359–368, Feb., 1922.)—The object of the paper is to show that, given gaseous mixtures of constant composition, a variation in the energy of the electric spark required to ignite them, dependent on the character of the spark, is to be anticipated on thermal considerations alone, i.e. without reference to ionisation of the gas.

A constant quantity of heat, Q, is supposed to be supplied under four different conditions: (1) instantaneously at the origin, (2) at the origin at a uniform rate during the time T, (3) instantaneously over a spherical surface of radius *a*, (4) instantaneously throughout a spherical volume of radius *a*. Under these circumstances the temperature $\theta$ at any point in the medium at a distance $r$ from the origin and at a time $t$ after heating begins can be deduced from the equation $kr^2d^2\theta/dt^2 + 2kd\theta/dr = r.d\theta/dt$, where $k$ is the thermometric conductivity of the medium. Assuming $k = 0{\cdot}5$, C (the thermal capacity per unit volume) $= 0{\cdot}00014$, $Q = 0{\cdot}001$ cal., and the ignition temperature of the mixture to be 700° C., it is deduced that the "incendivity" of the four sources of heat considered above are in the proportion 3·16, 2·62, 4·605, 3·16. The "incendivity" is measured by the greatest volume of the mixture that can be simultaneously raised (by conduction of heat only) to a temperature not less than the ignition temperature (700° C.), the radius of the source in cases (3) and (4) being taken as 0·1 cm. It is shown, however, that much more effective distributions of temperature can be obtained by further increasing the size of the source of heat. The incendivity of a source of small rate of heat supply may be very much less than that of an instantaneous source of the same total heat. Arguing solely on the distribution of heat by conduction, it is to be expected that the effectiveness of a source of ignition will be improved by spreading it over a surface rather than by concentrating it into a small space. A number of simultaneous sparks close together in parallel should be more effective than a single spark of the same length and same heat content. T. B.

**1330.** *Specific Heat of Superheated Water-Vapour for Pressures from 20 to 30 Atmospheres.* **O. Knoblauch.** (Zeits. techn. Physik, 3. 2. pp. 39–40, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The experiments described are in continuation of three former investigations, where the specific heat of steam had been determined from 1 to 20 atmos.

The vapour was heated in a water-tube boiler with oil, and superheated to the desired temperature by means of two successive electric heaters. It was then cooled in a condenser, and the specific heat $C_p$ determined. The heat loss from the condenser was separately determined after each experiment. Special precautions were taken to make this loss as small as possible, the vessels being surrounded by a steam jacket and 12 protecting electric heaters being placed between the vessel and the jacket. Constancy of temperature was tested by means of 26 thermo-elements placed in various positions within the apparatus. The amount of steam condensed amounted to about 50 to 70 kg. per hour. The results obtained at pressures 20 to 30 atmos. agree well with former results. Plotting $C_p$ against T, and connecting points corresponding to equal pressures by a curve, it is shown that these $C_p$ isobars rise very quickly as the saturation point is approached, indicating that $C_p$ would become infinitely great at the critical point. Full numerical results are promised shortly. T. B.

**1331.** *Specific Heats of Air, Steam, and $CO_2$.* **W. D. Womersley.** (Roy. Soc., Proc. 43. pp. 483–498, Feb. 1, 1922.)—The specific heats have been determined at temperatures 1000°–2000° C. by means of Hopkinson's recording calorimeter [see Abs. 1015 (1907)], in which many improvements, however, have been made. A mixture of hydrogen and air is exploded in a cast-iron calorimeter, the walls of which are lined with a continuous copper coil. This coil forms one of the arms of a Wheatstone bridge, and measurement of its resistance at a given time (about 1 sec.) after the explosion gives the amount of heat lost by the gas to the coil in this interval. A small correction to this is made for the heat conducted to the teak lining between the coil and the walls. The total amount of heat given by the chemical combination of H and O is known from the amount of H burnt as given by chemical analysis before and after the experiment. The temperature to which the gas is raised is given by the recorded pressure curve. Hence the specific heat of the gas mixture in the calorimeter is readily calculated. By varying the quantities of each constituent, it is found possible to calculate separately the specific heats of both steam and air. Similar experiments with CO and air or CO and O gave the necessary data for the specific heat of $CO_2$. Representative films are given to show the nature of the curves recorded. The main results are given in tables and in a curve showing "Energy in gas in cals. per gm.-mol. above 100° C." The experiments having been made only between 1000° and 2000° C., these curves are completed from results given by Swann (100°–200° C.) and Holborn and Henning (up to 1000° C.). T. B.

**1332.** *Life Tests of Platinum–Platinum-Rhodium Thermo-couples.* **C. O. Fairchild** and **H. M. Schmitt.** (Chem. and Met. Eng. 26. pp. 158–160, Jan. 25, 1922.)—The tests were carried out as a preliminary to a research on the relative efficiency of different types of porcelain protection tubes for thermo-couples. Two distinct makes of rare-metal couples were studied, one of American and the other of English manufacture. The tests consisted of prolonged heating to high temperatures and to treatment with fused borax. Quite considerable changes were observed in the English alloy wire (nominally 90 % Pt and 10 % Rh). Analysis showed that this was probably due to the presence of iron as impurity, 0·34 % Fe being found in the alloy. Later a new supply of English wire was submitted for test. The new sample was free from iron. This behaved quite satisfactorily under severe test, so the rapid deterioration of the earlier couples when exposed to high temperatures was caused mainly by the presence of iron as impurity. E. G.

**1333.** *On the Lags of Thermometers.* **A. R. McLeod.** (Phil. Mag. 43. pp. 49–70, Jan., 1922.)—An extension of a former paper [Abs. 457 and 677 (1919)]. The paper deals with the "lag" of thermometers when the initial and surface conditions are somewhat different, and refers particularly to problems in connection with air-temperature measurements by means of aeroplane observations. It is of a mathematical character, and the original should be consulted for details of the numerical computations. E G.

**1334.** *Radiation Equilibrium in Opaque Solid and Duane's Hypothesis* **A. G. Worthing.** (Frank. Inst., J. 193. pp. 252–253, Feb., 1922.)—Discusses Duane's hypothesis on the origin of the radiation of an opaque uniformly heated body [see Abs. 346 (1916)], from which it is to be inferred that the natural radiation from the ultimate sources has the characteristics of black-body radiation for free space. This is only the case when $k/\lambda$ is a constant, $k$ being the extinction coefficient and $\lambda$ the wavelength. Assuming the constancy of $k/\lambda$, it is necessary to modify Duane's assumption (3) to read "the energy radiated per hit is, on the average, proportional to the fourth power of the speed of the free electron and to the square of the index of refraction for the radiation emitted." This means that the ratio of the energy radiated per impact to the kinetic energy of the impacting electron is proportional, on the average, to the square of the ratio of the velocity of propagation of the radiation in the solid to that *in vacuo.* It is indicated that these conclusions, combined with others arrived at independently in other lines of research, give a satisfying physical concept of the processes which may underlie the emission of radiation by its ultimate sources. J. W. T. W.

**1335.** *Kinetic Stability.* **T. J. I'A. Bromwich.** (Phil. Mag. 43. pp. 70–72, Jan., 1922.)—Points out what is felt to be a misleading statement on the subject of kinetic stability in a recent Adams Prize Essay by J. H. Jeans (*Problems in Cosmogony and Stellar Dynamics*). The passage in question occurs in Art. 27. What appears to have been overlooked by Jeans is that these systems are not rendered unstable until frictional terms are introduced, the amount of the friction being proportional to the *relative* velocity. E. H. B.

**1336.** *Thermodynamical Theory of Explosions.* I and II. **J. B. Henderson** and **H. R. Hassé.** (Roy. Soc., Proc. 100. pp. 461–482, Feb. 1, 1922.)—The present paper contains an application to the problems of internal ballistics of the recent advances in the thermodynamics of dissociation and in the thermodynamics of the variation of specific heats of gases with temperature, with the result that the whole indicator diagram of a gun can now be calculated from the chemical composition of the propellant, combined with a table of heats of formation from the elements of the propellant and its products, and one set of laboratory experiments to determine the rate of burning of the solid propellant and its variation with pressure. L. H. W.

**1337.** *Vapour Pressure of Metallic Calcium, 500–700° C.* **N. B. Pilling.** (Phys. Rev. 18. pp. 362–368, Nov., 1921.)—A drawn wire of calcium was coiled into an open helix and placed in a glass tube which was then evacuated and heated to a definite temperature for a definite time. From the loss of weight due to evaporation the vapour pressure was computed by using a formula derived from the kinetic theory but involving a correction factor for the reflection of molecules by the walls of the hot tube. This factor was assumed to be a constant of the apparatus and was determined by making measurements for zinc and cadmium whose vapour pressures are known. The Ca used had 1·6 % Mg and 1·25 % $CaCl_2$. The values obtained for 500° to 700° C. are well represented by the formula: $\log p = 9{\cdot}73 - (10{,}170/T)$, the corresponding equations for Zn and Cd being $9{\cdot}41 - (7070/T)$ and $9{\cdot}02 - (5940/T)$ respectively.

*The vapour pressure of liquid calcium, computed* using Richards's relation between the vapour pressures of liquid and solid phases, is given by the equation $\log p = 9{\cdot}27 - 9670/T$. From this equation the *boiling-point* comes out 1240° C. AUTHOR.

**1338.** *Vapour Pressures of Aqueous Solutions of Nitric Acid.* **W. C. Sproesser and G. B. Taylor.** (Am. Chem. Soc., J. 43. pp. 1782–1787, Aug., 1921.)—The total and partial vapour pressures of nitric acid solutions of concentrations approximately 20, 40, 56, 68 and 80 % by weight at temperatures of 0°, 35°, 50°, 65° and 80° have been measured. Attempts to measure the vapour pressure of 90 % nitric acid were unsuccessful owing to decomposition of the acid at all the experimental temperatures except at 0°. AUTHORS.

**1339.** *Optical Observation of the Thermal Agitation of the Atoms in Crystals.* **C. V. Raman.** (Nature, 109. p. 42, Jan. 12, 1922.)—Larmor has suggested [Abs. 279 (1919)] that there should be some degree of scattering when light traverses a crystal, the intensity of the scattering being a measure of the thermal agitation within the crystal. Calculations indicate that transparent quartz should scatter light 9½ times as strongly as dust-free air at normal temperature and pressure. A scattering of approximately this magnitude in clear quartz was detected photographically by Strutt [Abs. 1018 (1919)], but was ascribed by him to inclusions which he assumed were present in the crystal. Experiments carried out by the author showed that the scattering of light by quartz could be observed visually. For this purpose a block of the crystal with smooth polished faces was immersed in a tank of clean distilled water to minimise surface reflections, and sunlight was focused within the crystal. The blue track of the beam in the crystal may be readily observed, and its intensity can be judged by comparison with the scattering in saturated ether vapour. A. W.

**1340.** *Principles of Internal Ballistics.* **J. Proudman.** (Roy. Soc., Proc. 100. pp. 289–305, Dec. 1, 1921.)—The principal features are the methods of determination of the rates of burning of propellants and the treatment of the mathematical equations relating to the motion of the shot in the gun. L. H. W.

**1341.** *The Mechanism of Molecule Separation in Crystals.* **M. Volmer and I. Estermann.** (Zeits. f. Physik, 7. 1. pp. 13–17, 1921.)—If a saturated vapour at pressure $p_D$ is in contact with a condensing surface of vapour pressure $p_K$, the weight, G, separated per cm.² per sec. is $G = a\sqrt{M/T} \,.\, (p_D - p_K)/\sqrt{2\pi R}$ [see Abs. 1357 (1916)]. The velocity $v$, with which the surface area advances in the direction of its normal, is $v = G/s$, where $s$ is the sp. gr. of the condensed substance. This can be applied to the case of a crystal at constant temperature in its saturated vapour. The values of $\alpha$ and of $p_K$ may have different values in different directions, so that a crystal grows at different speeds in different directions. It is probable that $p_K$ has different values also for the different lattice planes. Experiments are described on the growth of globules of Hg at low temperatures, which tend to prove that it is not the vapour-pressure difference $p_K$, but differences in $\alpha$, which provide the decisive factor in the rate of growth of a crystal. Observations on this rate of increase in various directions lead to the conclusion that a molecule on entering the field of force of the surface of a crystal remains for a time in a state corresponding to "adsorption," when it either (1) again vaporises, (2) is added on to the edge of the crystal, or (3) coincides with others to build a new lattice plane. T. B.

**1342.** *The Problem of Radiation Polarisation on the Quantum Theory.* **N. Bohr.** (Zeits. f. Physik, 6. 1. pp. 1–9, 1921.)—In a recent publication, Rubinowicz [*ibid.* 4. 3. pp. 343–346, 1921], by means of an interesting consideration, has sought to draw a generalisation respecting the state of polarisation to be expected according to the quantum theory from the radiation emitted by a given atomic system. The author shows that great objections can be raised against Rubinowicz's proposals, and that it is scarcely possible to defend the above-mentioned generalisation with respect to the radiation polarisation. On account of the outstanding importance of the problem treated, the author gives a detailed account of it, so that considerations may be advanced from as many sides as possible. The first item discussed is that the radiation emitted by an atomic system cannot on the quantum theory be directly connected with the motion of the emitting system, as should be the case from the classical electrodynamic standpoint. It is assumed that an atom can exist in a series of stationary states without radiation, while every emission is connected with a complete transition between two such states. The constitution of the radiation is then dealt with on the quantum theory, two different modes of investigation being described. The first method is chiefly directed to the emission and absorption processes of radiation, and certain general conclusions are drawn from them, among these being the so-called correspondence principle, which affords a simple asymptotic agreement between the spectrum and the motion of an atomic system. It appears that during a transition between two stationary states the radiation emitted should in general show elliptical polarisation, and that only in special cases, where for every motion of the system the corresponding oscillation component consists in a linear displacement in a definite direction or in a circular rotation about a given axis, can the emitted radiation exhibit a so-called linear or circular polarisation. An interesting example of such a special case is a system consisting of an electron which moves in an axially symmetric field. In this case the motion, when stationary states are assumed, can be regarded as a superposition of a number of linear oscillations parallel to the axis and a number of circular rotations about this axis. From the correspondence principle it follows that the former oscillations give rise to a radiation of linear polarisation and the latter to a radiation of circular polarisation, a consequence which is in complete agreement with observations on the Zeeman and Stark effects of hydrogen lines. The second mode of treatment depends on the analogy which an electromagnetic radiation field enclosed in a limited space of perfectly reflecting walls bears to an ordinary mechanical system, and which Rayleigh and Jeans have pointed out for the theory of thermal radiation. The unique result is found that the energy which is ascribed to the separate special oscillations in the stationary states of the radiation field is a whole multiple of the quantity *hν*, where *ν* denotes the frequency of the respective wave. This result is not only in accord with the hypotheses used in Debye's deduction of the thermal law of radiation, but has led to important results for the conception of radiation processes on the quantum theory. This mode of treatment is worked out very comprehensively, and renders the service of bringing together under one formulation such different phenomena as the photoelectric effect and stationary light-waves. The author concludes the assumption to be valid that the radiation which corresponds to a transition between two stationary states is in general elliptically polarised, and that every value of axial relationship can occur in the ellipticity under suitable circumstances. H. H. Ho.

**1343.** *Cohesion and Equation of State for Dipole Gases.* **H. Falkenhagen.** (Phys. Zeits. 15. pp. 87–95, Feb. 15, 1922. Abstract of Dissertation, Göttingen.)—Since Debye succeeded (for tetrapole gases) in showing that the van der Waals attraction could be regarded as a system of electric forces between the molecules, which latter were dealt with as electric charges, it remained to extend the investigation to dipole gases, and the present paper contains an attempt to find a quantitative expression for the attraction in this case. Here the symmetry relationships of Debye's problem do not occur, and the orientations of the dipole axes have to be taken into account. Part I contains the mode of calculation employed. Section 1 of it discusses the general hypothesis of statistics, of which section 2 contains an application to the given problem. Section 3 evaluates the potential energy of two dipoles with respect to each other. In section 4 the second virial coefficient is obtained. Part II of the paper contains a comparison of the theoretical and experimental results. Section 5 is concerned with sulphur dioxide, Roth's measurements in the equation of state being utilised. Section 6 deals with Holst's data for ammonia; section 7, with Jakob's data for water; and section 8 with Weigt's measurements for carbon dioxide. The final section, 9, discusses internal friction and surface tension. An approximation at higher temperatures for the internal friction of dipole gases is derived, and tables of experimental data are included showing a quite good agreement between theory and experiment. The difficulty attending a theory of surface tension lies in the fact that with associating liquids the dipoles associate. The Boltzmann principle leads here to an integral equation, which may perhaps be solved by an approximation method. The author gives a semi-convergent approximation formula for the second virial coefficient at low temperatures. The paper is mainly mathematical throughout. H. H. Ho.

**1344.** *The Relation between Statistical Mechanics and Thermodynamics.* **R. C. Tolman.** (Am. Chem. Soc., J. 44. pp. 75–90, Jan., 1922.)—There have been two main methods of investigating the relation between statistical mechanics and thermodynamics, namely, that of Gibbs and that of Boltzmann. Boltzmann's method, while perhaps somewhat less general than that of Gibbs, leads more directly to very important information concerning the behaviour of the individual molecules of the system, and has been adopted in the present paper. Since Boltzmann, important investigations of the relation between the statistical mechanical quantity, probability, and the thermodynamic quantity, entropy, have been made by Planck. The work presented here differs from that of Planck in two ways, namely: (1) No position is taken with reference to the quantum theory, although the results obtained can easily be modified in accordance with the Planck quantum theory by assigning, as he does, a definite location and finite size G to the regions into which is divided the generalised space used in representing the phase of the individual molecules. (2) Instead of somewhat arbitrarily defining entropy, as a constant into the log. of probability, the author endeavours to discover a statistical mechanical quantity which has the same derivatives with respect to the fundamental variables, energy E, volume $v$, and number of molecules N, as entropy. This leads to a somewhat different expression for entropy from that used by Planck, since the Planck expression, although depending on the energy and volume in the correct manner, does not make the entropy of a homogeneous system maintained at constant pressure and temperature vary proportionally to the number of molecules present. The Planck expression can, however, be brought into agreement by the addition of a term which is a function of the number of molecules present. Section II of the paper reviews in a fundamental way the derivation of the Maxwell-Boltzmann distribution law, while section III contains the main task of determining the thermodynamic significance of the quantities occurring in Maxwell's distribution law. The final section, IV, is devoted to a comparison of the expression obtained for the entropy of a system with that given by Planck. Both expressions have the same derivatives with respect to energy and volume, but different ones with respect to the number of molecules N. This is a fundamental difference, and explains the reason why Planck's expression for entropy is not satisfactory when considerations are to be undertaken which involve a change in the number of elements. The author's expression, which differs from that of Planck by an additive term, is shown to be necessary in order that the derivative of the entropy of the system with respect to number of molecules shall have its correct value. It is pointed out that the equations obtained in this paper connecting the statistical mechanical quantities occurring in the Maxwell-Boltzmann distribution law with thermodynamic quantities do not agree with the equations of Marcelin and Adams. H. H. Ho.

**1345.** *"The General Conditions of Validity of the Principle of Le Chatelier."* **A. J. Lotka.** (Am. Acad., Proc. 57. pp. 21–37, Jan., 1922.)—The derivation of the principle of le Chatelier from the laws of thermodynamics is familiar, and the author now approaches a converse problem, namely: What, in the broadest terms, are the conditions which a system must satisfy? The interest of this problem arises from the fact that there is reason to suspect these conditions may prove broader than the domain within which the laws of thermodynamics are conveniently applicable. A satisfactory solution of this converse problem may enable a rigorous application of the principle to be made to systems to which, from lack of sufficient data, it may be impossible, or from other causes inconvenient, to apply thermodynamic methods. For further details the original must be consulted. H. H. Ho.

# SOUND.

**1346.** *Binaural Location of Pure Tones.* **R. V. L. Hartley** and **T. C. Fry.** (Phys. Rev. 18. pp. 431–442, Dec., 1921.)—It is pointed out that to determine two coordinates of the sound source, angular position and distance, the simultaneous observation of both phase difference and intensity ratio for the two ears is necessary. Thus, contrary to the conclusions of certain observers, intensity ratio plays an important part in sound location. Using a method of analysis due to Stokes, the authors have prepared a series of *charts showing the intensity ratio and phase difference* for sources at various distances and angular positions emitting sound with a frequency from 310 to 1860 cycles and for two angular separations of the ears, 165° and 180°, assumed to be placed on a spherical head. These charts show the theoretical position of the source for any combination of phase difference and relative intensity which might occur with actual sources. Experiments to test this theory are suggested.
L. H. W.

**1347.** *Mechanical Actions of the Sound produced by a Telephone Receiver.* **K. Kurokawa.** (Inst. El. Eng. of Japan, J. No. 402. pp. 41–46, Jan., 1922.)—The paper describes, with photographic illustrations, some remarkable mechanical actions of sound, produced by a telephone receiver traversed by a rather large alternating current of telephonic frequency—namely: (I) Attraction or repulsion between a suspended disc and a sounding receiver, etc. (II) Pumping action of sound or a receiver, etc. (III) Driving of a small wheel by air currents induced by sound, and sucking up of powder along the inside of a tube and blowing it out through a side hole, etc. (IV) Dancing of grains of powder between the cap of a sounding receiver and a horizontal plate, etc. L. H. W.

**1348.** *Physical Characteristics of Normal and Abnormal Ears.* **J. P. Minton.** (Phys. Rev. 19. pp. 80–96, Feb., 1922).—*Sensitivity Curves for Normal and Abnormal Ears.*—Previous investigators have worked only with normal ears and their results are not as a rule corrected for the resonance properties of the diaphragms used. Rayleigh's curves are more reliable but do not extend above 768 double vibrations. In the present work a telephone receiver was used with a natural frequency above the range of tests, 5200 double vibrations, and its vibrational and electrical characteristics were determined so that the vibrational energy of the diaphragm could be calculated for any current of any frequency used. The currents were generated by means of an audion oscillating circuit, and a Wheatstone bridge was used in measuring the minimum audible current for both normal and abnormal ears; the readings in the case of normal ears were then converted into *minimum vibrational energy* and plotted *as a function of the frequency up to* 4000 *double vibrations.* Curves are given (1) for normal ears; (2) for ears diseased only in the middle ear; (3) for ears diseased only in the internal ear; (4) for ears having a combination middle and internal ear trouble.

*Discussion of Theories of Audition.*—The difficulties confronting each theory are briefly pointed out. In some ways the results obtained tend to confirm the Helmholtz theory, but it is hard to see how any mechanical theory can explain the absolute insensitiveness to a limited range of pitch which has been observed in cases of nerve deafness. AUTHOR.

## ELECTRICITY AND MAGNETISM.

### THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

**1349.** *Electromagnetic Wave Induction.* **K. Uller.** (Zeits. f. Physik, 8. 1. pp. 89–104, 1921, and 8. 3. pp. 193–201, 1922.)—In contradiction to the commonly accepted Faraday-Maxwellian theory of electromagnetic induction, the author contends that electromagnetic induction phenomena are essentially to be explained on the basis of a wave theory. Such phenomena originate in the incidence, under certain conditions, of a wave upon a surface of instability whereby a bound induction-wave, together with reflected and refracted waves, are produced. The conditions to be fulfilled in order that induction, which may be of two types, may arise are three: (1) a certain inequality must be satisfied between the properties characterising the surface of incidence and the form of the incident wave; (2) the wave normals must have a definite relation to the surface of instability, this relation being conditioned by the properties of the incident and refracted media and the wave form; and (3) the incident wave must possess a component normal to the surface of incidence, the induction being of one or other type according as this normal component is the electric or magnetic vector. The author develops the mathematical theory of electromagnetic induction along these lines. J. S. G. T.

**1350.** *Units of Field Intensity and Magnetic Induction.* **P. Langevin, A. Iliovici, A. Liénard, E. Brylinski,** and **J. B. Pomey.** (Rev. Gén. d'Él. 11. pp. 259–268, Feb. 25; 382–385, March 18; 424–426, March 25, and pp. 490–491, April 8, 1922. Papers read before the Soc. Franç. de Physique.)—This is a continuation of earlier discussions [Abs. 1616 (1921)]. Langevin argued that magnetic induction and field intensity must be quantities differing in nature, since their components transform differently when the units and coordinates are changed, and that there was no significance in their numerical equality *in vacuo*. He suggested new definitions of these quantities in order to conserve the invariance of the Maxwell equations. Abraham pointed out that Langevin had been misled by the fact that the flux of a vector is most simply expressed by oblique projections of the vector on the axes, made parallel to the coordinate plane, all three being multiplied by the determinant of the linear transformation; while, on the other hand, the line integral of a vector is most simply expressed by orthogonal projections on the axes. Maxwell's equations could be expressed, in the case of all the vectors, in invariant form, by means of either oblique or orthogonal projections, but a somewhat simpler result was obtained by using orthogonal projections for the first members of the equations and oblique projections for the second members. This Langevin had done, and his argument reduced itself to the verification of the fact that the orthogonal and oblique projections of one and the same vector are differently transformed when the axes are changed. Iliovici argued that the whole discussion turned upon the fact that the partisans and the opponents of the identity of field intensity and magnetic induction started from different definitions, and proposed a new definition of magnetic induction. Liénard, replying to Iliovici, showed that where P is the strength of a magnetic shell, and I is the field intensity, whether produced by the shell or by a current to which the shell is equivalent, the induction is given by the equation $I = P$, and not $I = \mu P$, as contended by Iliovici, arguing from an incomplete analogy between electrostatic and magnetic action. Brylinski offered further criticism of Iliovici's argument. Pomey stated that further consideration had brought him round to Abraham's view that magnetic induction and field intensity are quantities identical in nature, $\mu$ being a linear and vector function of zero dimensions. G. W. de T.

**1351.** *Maxwellian Tensions and Pressures in Magnetic and Dielectric Media.* **G. Gouy.** (Comptes Rendus, 174, pp. 510–515, Feb. 20, 1922. Rev. Gén. d'Él. 11. pp. 492–494, April 8, 1922.)—The author contends that the expressions for the forces in an electric or magnetic field are best stated in the form in which they were originally given by Maxwell in the case of a *magnetic* field, namely, a tension $BH/4\pi - H^2/8\pi$ along the lines of force and a transverse pressure equal to $H^2/8\pi$, where B and H have the usual significance in either the magnetic or electrostatic field. J. S. G. T.

**1352.** *On Tubes of Electromagnetic Force.* **E. T. Whittaker.** (Roy. Soc. Edinburgh, Proc. 42. 1. pp. 1–23, 1921–1922.)—The object of the present paper is to introduce certain surfaces, which will be shown to play the same part in the general electromagnetic field as Faraday's tubes of force do in electrostatic and magnetostatic fields. The surfaces here introduced, to which the author gives the name *calamoids*, may be regarded as a direct generalisation of Faraday's tubes, since they reduce to Faraday's electric tubes when the field is purely electrostatic, and to Faraday's magnetic tubes when the field is purely magnetostatic: and between these extreme types they provide a continuous transition. L. H. W.

**1353.** *Electron Theory of Metals in the Light of New Experimental Data.* **P. W. Bridgman.** (Phys. Rev. 19. pp. 114–134, Feb., 1922.)—Most of the information here contained has been given in other, more detailed, papers by the author. L. H. W.

**1354.** *Electromagnetism and the Principle of Reaction.* **G. Meller.** (Assoc. Ing. Él Liége, Bull. 1. pp. 37–80, Jan.–Feb., 1919; 2. pp. 25–96, Jan.–April, 1920, and 3. pp. 3–37, Jan.–Feb., 1921.)—Theoretical; unsuitable for abstraction. L. H. W.

**1355.** *Electrification of Phosphorus Smoke.* **J. J. Dowling** and **C. H. Haughey.** (Roy. Irish Acad., Proc. 36. pp. 50–59, Feb., 1922.)—If smouldering phosphorus be exposed to an electric field, the resultant smoke particles rising from it take up charges depending on the field. The particles appear to approximate to uniform size. These phenomena are investigated by (*a*) observing the rate of travel of the smoke across the field or by (*b*) measuring the charges carried by the smoke and yielded up, on striking, to a plate connected to an electroscope. It is found that the increase in charge on the particles occurs at equal periodic intervals as the field is increased; and the number of electrons attached is measured under given conditions. All values of electrons on a particle from 1 to 25 have been observed. If an accurate count of the particles could be made, it would be possible to determine the unit charge $\epsilon$ by these methods. An explanation is put forward for the apparent stability and cohesion of the smoke filament and for the fact that the mobility found for these smoke particles is about one thousand times as great as in the well-known experiments of Millikan on drops. P. E. S.

**1356.** *Experiments with an Electrified Pith Ball in an Ionised Atmosphere.* **D. Turner** and **D. M. R. Crombie.** (Roy. Soc. Edinburgh, Proc. 41. pp. 154–157, 1920–1921.)—A pith ball suspended from the centre rod of a charged Leyden jar provides an interesting and delicate method of demonstrating the ionised atmosphere surrounding flames and incandescent bodies. In an ionised atmosphere of sufficient intensity, provided the suspending fibre is of high insulating quality, the ball rapidly loses its charge and falls back towards the centre rod of the jar, from which it receives a fresh charge and is violently repelled, only to repeat the performance; thus an oscillation is set up, the rapidity of which is governed chiefly by the length of the suspending fibre. The effect upon the pith ball appears to be independent of the nature of the charge given to the jar. A. W.

**1357.** *Electrical Charge of the Atmosphere and the Height of the Barometer.* **W. J. Humphreys.** (Monthly Weather Rev. 49. pp. 570–571, Oct., 1921.)—It is shown to be very improbable that changes in the electrification of the upper atmosphere are ever responsible for the origin of cyclones or anticyclones, as has been sometimes suggested. Simple considerations show that a uniform charge on an approximately circular extent of the upper atmosphere, sufficient to produce with an equal and opposite charge on the earth a vertical potential gradient of 100 volts/m., would, by attraction, increase the barometric pressure by no more than $1/(3 \times 10^9)$ mm. If, on the contrary, the upper atmosphere were charged to the same extent all round the earth, instead of locally, the effect would be a decrease of barometric pressure of the above amount. In the first case the local charge to produce a pressure change of 0·3 mm. would have to be sufficient for a vertical potential gradient of $3 \times 10^6$ volts/m. M. A. G.

## DISCHARGE AND OSCILLATIONS.

**1358.** *Ionisation in Moist and Dry Air.* **J. J. Nolan,** and **J. T. Harris.** (Roy. Irish Acad., Proc. 36. pp. 31–49, Feb., 1922.)—In a previous paper [Abs. 473 (1921)] an account was given by one of the authors of the ionisation produced in moist air by a radio-active source. In the present paper the composite nature of the ionisation in moist air has been demonstrated by two methods, the "air-current method" and the "alternating field method." The effect of extreme drying has been investigated. The effect on negative ionisation is to increase the numbers of ions of the more mobile type, and to cause the disappearance of the ordinary ions. With positive ionisation, the more mobile ions are also found in greater numbers, although the ordinary ions are still present. Doubly-charged positive ions are found in very dry air. Some indications are obtained of the presence of free electrons. A. B. W.

**1359.** *Ionisation Potential of Selenium Vapour.* **A. D. Udden.** (Phys. Rev. 18. pp. 385–388, Nov., 1921.)—*Ionisation potential of selenium vapour* was determined from current-potential curves obtained with a four-electrode, pyrex glass tube. The ionisation potential comes out 12·7 ± 0·4 volts. Putting this value in the quantum equation we get 980 Å. as the short-wave limit of the Se spectrum. L. H. W.

**1360.** *Comparison of the Thermionic and Photoelectric Work Function for Platinum.* **O. Koppius.** (Phys. Rev. 18. pp. 443–455, Dec., 1921.)—*Variation of Photoelectric Effect with Temperature, to 420°.*—(1) *Pt filaments coated with oxides of Ba and Sr* were mounted in an evacuated tube with a quartz window and could be heated electrically to any desired temperature. The *photoelectric current* received by a copper oxide-coated Faraday cylinder when a strip was illuminated with light from a quartz arc was measured with a sensitive electrometer, and was found to increase rapidly with the temperature reaching a value, on first heating to 420°, about 68 times as great as at 20°. The *long-wave limit* was found to shift with increasing temperature from 2860 to about 3800 Å., the corresponding *work function* changing from 4·31 to 3·24 volts. On cooling, however, the sensitiveness and wave-length limit did not return to their original values, except very gradually, showing marked *time-lag effects,* due probably to changes in the oxide surface. (2) *Pt strips,* uncoated, were tested in the same manner. After preliminary treatment by repeated heating to 900°, the *current* was found to be independent of the temperature to 500°, except for a slight decrease due to the magnetic effect of the heating current, and the *long-wave limit* remained constant within 1 per cent. at 2570 Å. Hence the *work function,* or work necessary to detach an electron photoelectrically from Pt, comes out 4·80 volts, which is close to the values found for the corresponding thermionic work function. The *relative energy of spectrum lines of Hg,* 2301 *to* 2804 Å. from an arc in quartz, after dispersion by a quartz spectrograph, was determined with a Coblentz thermopile. Author.

**1361.** *Behaviour of Free Electrons towards Gas Molecules.* **H. B. Wahlin.** (Phys. Rev. 19. pp. 173–186, Feb., 1922.)—CO behaves like N; electro-negative gases attach electrons more readily than do electropositive gases; the degree of saturation of hydrocarbons does not make much difference. The *mobility of negative ions in chlorine, ethane, and ethylene* was found by the Rutherford a.c. method to be, respectively, 0·73, 1·30, and 0·91 cm./sec. per volt/cm. at atmospheric pressure. L. H. W.

**1362.** *Effect of Oxygen and Hydrogen on the Emission of Electrons from Hot Platinum.* **L. Lockrow.** (Phys. Rev. 19. pp. 97–113, Feb., 1922.)—*Thermionic Emission from a Platinum Filament.*—Previous observers have reported such conflicting results as to the effect of gases on the emission that a series of 20 tests were carried out by the author to determine the cause of these discrepancies. (1) *The effect of oxygen and air* on the emission was found to be to decrease it slightly, in agreement with the observations of Richardson, H. A. Wilson, and others. This effect is temporary and is not due to the formation of heavy ions;

and while it may accompany the formation of an oxide of platinum, no evidence for this was obtained. (2) *The effect of hydrogen* on the emission from pure platinum is probably nil. For in those cases in which the hydrogen causes a "permanent increase," that is an increase which remains after the removal of the hydrogen, the author's tests indicate that the effect is due to grease or oil vapour, although the hydrogen may hasten the action; and the large "temporary increase" usually observed when hydrogen is admitted is found to disappear upon heating the filament a long time in air and hydrogen, and hence is probably due to the action of hydrogen, not on the Pt itself but on impurities contained in the filament. (3) *Richardson's constants for pure Pt* were found to be: $A = 9900$; $b = 52,000$. These values are lower than those obtained by others and are subject to errors inherent in the resistance method of measuring temperatures. (4) *The thermionic work function for platinum* computed from the value of $b$ comes out 4·46 volts, as compared with 4·80 volts obtained by Koppius for the corresponding photoelectric function. AUTHOR.

**1363.** *Fatigue Phenomena of Alkali Metal Cells in the Neighbourhood of the Discharge Potential; Influence on the Results of Photometric Measurements.* **H. Rosenberg.** (Zeits. f. Physik, 7. 1. pp. 18–64, 1921.)—Near to the discharge potential alkali-metal cells filled with rare gases exhibit (1) rapid fatigue and recovery phenomena which effect apparent non-proportionality between the light intensity and the photo-current, and (2) slow alterations in the sensitiveness of the cells which may also be regarded as a species of fatigue phenomena. The cause of the fatigue is found to be adsorption of a positively-charged layer of gas at the alkali metal, but it remains undecided if absorption of electrons or diminution of the strength of field is the ultimate cause of the fatigue. The process appears to be connected with the appearance of intense shock-ionisation. The pure photo-effect is strictly proportional to the amount of the incident light and a photometric method has been devised which allows of the measurement of brightness with an accuracy of about ± 0·1 %. T. H. P.

**1364.** *The Low-Current Arc.* I. *Arc in Air at Atmospheric Pressure.* **V. L. Chrisler.** (Astrophys. J. 54. pp. 273–284, Nov., 1921.)—*Low-current arc in air.—Potential–current curves* up to 0·5 amp. were obtained *for electrodes of various materials* (C, Ag, Cd, Cu, Fe, Sn, Zn, and salts of Ba, Ca, Cs, Na, and Sr); also the *kathode- and anode-falls and the gradients in the centre* were measured with the help of probing Pt wires. As the current is increased the glow form of the arc changes suddenly to the true-arc form and at the same time the kathode-fall drops sharply, in the cases of Ag, Cu, and Fe changing from 214 to 28 volts, from 290 to 16 volts, and from 205 to 24 volts respectively. Ag, Cu, Fe, and Pt all gave the glow discharge up to 0·1 ampere. The true-arc form probably begins with the volatilisation of the electrode material and the ionisation of the vapour. The gradient in the centre of the arc is proportional to the length of the arc, decreases with increasing current, and varies in step with the ionisation potential of the metal vapour from the electrode. AUTHOR.

**1365.** *Time and Pressure Measurements in the Corona.* **C. S. Fazel.** (Phys. Rev. 19. pp. 157–164, Feb., 1922.)—The discharge took place from a fine wire inside a concentric tube. By means of a sensitive differential gauge it was found that the pressure at the tube was 0·004 cm. of water higher than at the wire, *for both a.c. and d.c. discharges.* Studies made with a recording mica diaphragm gauge showed that on starting the d.c. discharge the pressure rose gradually, reaching in about 1¼ sec. a limiting value proportional to the current. The curves for a.c. discharges were the same except that superposed on the d.c. curves were periodic pressure changes with twice the frequency of the alternating voltage and with an amplitude of 0·3 cm. of water. When the wire was heated without the discharge, with either alternating or direct current, the pressure curve took about 20 secs. to reach its limiting value and showed no periodic variations. If when the steady state was reached the corona discharge was started, the pressure either decreased to a lower limiting value, or increased to a maximum and then decreased to a limiting value lower or higher than before, depending on the voltage of the discharge. Evidently several effects are superposed in this case. The experiments show the existence of characteristic pressures in the corona in addition to the pressure due to the heating of the gas by the current through the wire. AUTHOR.

**1366.** *Pressure in the Corona Discharge.* **J. Kunz.** (Phys. Rev. 19. pp. 165–172, Feb., 1922.)—*Theory of Pressure Effects Due to the Corona Discharge, in Terms of Ionic Mobility.*—The characteristic pressure effect is an excess pressure of from 1 to 3 cm. of water inside a tube concentric with the discharge wire. Assuming that the momentum given the ions by the electric field is transferred to the gas, the author shows that the excess pressure is $i/4\pi u$, where $i$ is the current per unit length of wire and $u$ is the mobility. Using this expression, the *positive mobilities in* H, N, $CO_2$, O, *and* $NH_3$ *are computed* from the observed pressure differences, and come out respectively 1·51, 0·50, 0·16, 0·23, and 0·31 times $10^{-2}$ cm./sec. per volt/cm. The first three values are about half those measured by Hess in the wind of ions from radio-active substances, while the value for O is only one-eighth, the low value being perhaps due to ozone. The results so far refer to the mean mobility. Assuming that there are two types of ions, the *percentage of heavy ions* comes out about 13 for O. The time for the pressure to rise to its limiting value is computed and comes out in rough agreement with the measurements of Fazel; and an explanation is suggested for the form of the pressure curves obtained by Fazel [see preceding Abs.] with a.c. discharges. AUTHOR.

**1367.** *A Generalisation of Paschen's Law, Applicable to Polarisable Dielectrics.* **C. E. Guye.** (Arch. des Sciences, 4. pp. 5–9, Jan.–Feb., 1922. Comptes Rendus, 174. pp. 445–448, Feb. 13, 1922.)—Paschen has shown that in the case of disruptive discharge between plates separated by distance $a$ in a gas at pressure $p$, the explosive potential V is given by $V = f(pa)$. This result is theoretically applicable only to perfect gases. From a consideration of the mean free paths of the ions produced by collisions in the gas, when the p.d. between the plates is of the order of the explosive potential, the author deduces a more general relation in the form $V = F(Ma)$, where M is the number of molecules of the gas per unit volume. In the case of a polarisable dielectric, taking account of the molecular field due to ions, in addition to the external field, the relation takes the form $[A]V = F(Ma)$. [A] is a function of the pressure of the gas and hence of M; it depends also upon the nature and temperature of the gas, and is readily calculated from the value of the dielectric constant of the gas. J. S. G. T.

**1368.** *Explanation of the Influence of a Transverse Magnetic Field upon the Sparking Potential.* **E. Meyer.** (Ann. d. Physik, 67. 1. pp. 1–12, April 12, 1922.)—Further investigation of the effect of a transverse magnetic field upon the value of the sparking potential between two brass electrodes separated by an ebonite ring, the discharge occurring through orifices of various sizes, confirms the previous result [Abs. 786 (1919)] that the value of the sparking potential, in the presence of the magnetic field, depends upon the cross-sectional area of the spark-gap. The results support the conclusion that owing to the action of the magnetic field some of the electrons are driven to the wall of the orifice, out of the region of production of ionisation by collision. J. S. G. T.

**1369.** *Luminescence of Flame Ions in the Electric Spark.* **H. Greinacher.** (Phys. Zeits. 23. pp. 65–69, Feb. 1, 1922.)—A horizontal blowpipe flame was used between two Pt sparking points about 3 cm. apart, the flame at this point having a diam. of 0·5 to 1·0 cm. The spark was focused on the slit of a spectrograph by means of a lens. With this apparatus the spectra of the alkali metals were investigated in the flame, in the marginal zone just outside the flame, and in the air beyond. The results obtained show that the ions of hydrogen and the alkali metals wander away from the flame. The metal ions move principally towards the negative electrode, though some go towards the positive electrode. Of the metals investigated (Li, K, Rb, Cs, Tl, and Sr) only Tl shows little decided polarity. The results obtained are illustrated by numerous spectrograms. A. W.

**1370.** *Mechanical Disintegration caused by Positive Ions.* **H. P. Waran.** (Phil. Mag. 43. pp. 226–229, Jan., 1922.)—While studying the effect of a transverse magnetic field on the spectrum of an electric discharge through rarefied gas it was found that the walls of the discharge tube suffered disintegration where the field was applied. Using a nitrogen tube excited by the unrectified current from an induction coil, the discharge was found to split up into two streams, corresponding to the "make" and "break" currents. The positive ions in the two streams travel in different directions and so are deflected to opposite sides of the capillary. With a heavy discharge of about 15 milliamps and a field of the order of 10,000 c.g.s. units the effects were intensified and in a few seconds corrosion of the glass walls took place under the sand-blast action of the ions. When examined under the microscope it was found that a series of short little grooves had been cut in the glass, all converging in a direction parallel to the axis of the tube. The opposite side of the tube showed the same effect, but with the grooves converging in the opposite direction. The grooves are on the average about the same length and occur evenly spaced; they start from about the same azimuth. These points are being further investigated. A. W.

**1371.** *Certain Types of Electric Discharge.* **D. N. Mallik** and **A. B. Das.** (Phil. Mag. 43. pp. 216–222, Jan., 1922.)—A continuation of previous work [Abs. 1278 (1916)]. In the present experiments three cylindrical tubes of different lengths were used. The electrodes consisted of thin rods concentric with the tubes. The characteristics of the discharge in these tubes under different conditions of pressure and applied voltage, and also the effects of a transverse magnetic field, are described, and the results are in agreement with the theory previously developed. The characteristic changes in these discharge tubes and the characteristic differences between them arising from a difference in length, correspond to the peculiarities exhibited by the curves connecting pressure and p.d. in them. When the striated discharge is placed in a transverse magnetic field the number of striæ increases. In the experiments dealt with, the transverse field was obtained by means of a coil surrounding the tube longitudinally, and it was found that the striæ become inclined to their original directions, the inclination being in the opposite direction when the current in the coil, and therefore the magnetic field, was reversed. A possible explanation of these effects is given. A. W.

**1372.** *Currents in Antennæ due to Atmospheric Electricity.* **F. Schindelhauer.** (Phys. Zeits. 23. pp. 36–39, Jan. 15, 1922.)—In the experiments described the antennæ were earthed through a resistance, and the p.d. at the ends of this resistance was measured by means of a Dolezalek electrometer. The currents thus observed exhibit a daily variation, and the values obtained in June and July ($0{\cdot}5 \times 10^{-8}$ amp. for a low antenna and $0{\cdot}8 \times 10^{-8}$ amp. for a high antenna) were considerably less than those found in Oct. and Nov. ($2{\cdot}7 \times 10^{-8}$ and $18{\cdot}2 \times 10^{-8}$ amp.). A. W.

**1373.** *Diffraction of Plane Electromagnetic Waves by a Perfectly Reflecting Sphere.* **F. P. White.** (Roy. Soc., Proc. 100. pp. 505–525, Feb. 1, 1922.) —The formal series solution, both for plane waves and for the waves from a Hertzian oscillator, has been given by several physicists. When the radius of the sphere is small compared with the wave-length the series converge rapidly and are suitable for computation, but for a large sphere the important terms are far on in the series and the latter must be transformed in order to obtain formulæ which may be of use. This problem has received much greater attention in the case of the Hertzian waves than in that of plane waves, and this paper is devoted to the latter case. T. J. I'A. Bromwich [Abs. 601 (1920)] has shown that at a large distance $r$ from the sphere of radius $a$ the scattered wave is given by components in the directions of $r$, $\theta$, $\phi$ respectively $X = c\alpha = 0$, $Y = c\gamma = \partial M/\partial\theta - \partial N/\partial\phi \,.\, 1/\sin\theta$, $Z = c\beta = \partial M/\partial\phi \,.\, 1/\sin\theta + \partial N/\partial\theta$, where M and N are infinite series expressed in terms of the Riccati-Bessel functions, $S_n(ka)$, $E_n(ka)$, tabulated by the B.A. Committee for integral values of $n$ and $ka$ up to 10. The incident wave is of unit amplitude, travelling along the axis $\theta = 0$, polarised in the plane $\phi = \pi/2$, and has wave-length $2\pi/k$. Bromwich obtained approximations, respectively, agreeing well with the author's test calculations from the original series for $ka = 10$ over the range $\theta = 0$ to 90°, and fairly over the range 170°–180°, but diverging markedly over the rest of the range. The author transforms M and N into series depending on the zeros of Bessel functions, together with a contour integral along a "path of steepest descent." The series contribution being small, the contour integral, evaluated as an asymptotic series, after Debye, gave an approximation, the first term of which is identical with

Bromwich's first approximation for points not near to the axis $\theta = \pi$, and a second approximation was obtained. This gave improved agreement with Proudman's figures [Abs. 195 (1918)] from 0°–90°, but breaks down for reasons given in the paper as $\theta$ approaches $\pi$, and M and N are then transformed into (1) a series (of negligibly small value) depending on the roots of a Bessel function; (2) several comparatively simple contour integrals which are negligible in the earlier case, but important now—approximations to these are easily obtained; (3) a contour integral involving Bessel functions of order $s$ and argument $x$ along a curve in the $s$-plane passing through the point $s = x$. The evaluation of (3) involves much complication and labour. The result is a much better agreement with Proudman's figures for the range 170°–180°. For larger values of $ka$ the next terms in the approximation would have to be calculated, which would require enormous labour by this method. The intermediate range, 90°–170°, is thus still without adequate treatment. G. W. DE T.

**1374.** *Harmonic Synchronisation of Electric Oscillators.* **Mercier.** (Comptes Rendus, 174. pp. 448–450, Feb. 13, 1922.)—A brief note on the phenomena characterising the synchronisation of two circuits oscillating under their mutual action, and the illustration of such phenomena by amplified oscillations produced by three-electrode valves. The method is applicable to the production of synchronisation effects between a number of oscillators arranged in cascade, the frequency in any circuit being approximately a harmonic of that in the preceding circuit. In this manner it has been found possible to produce such effects between oscillations of frequency 50 per sec. and $5 \times 10^6$ per sec. J. S. G. T.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**1375.** *Insulation of Fine Wires in Platinum-Resistance Thermometers.* **J. J. Manley.** (Phil. Mag. 43. pp. 95–96, Jan., 1922.)—The construction of Pt thermometers, having bulbs with a diameter of 2 mm. and resistance wires the thinness of which ranges from 0·06 to 0·02 mm., presents practical difficulty, and the present paper describes various methods of insulating the two limbs of the Pt loop. The method recommended is the following: A glass rod about 1 or 2 mm. in diam. is prepared and a needle-eye formed at one end. Having fixed one end of the resistance wire to the lead, the other end is drawn through the eye in the glass rod and brought up and secured to its lead. Holding the leads vertically, the rod will, if of appropriate weight, pull and maintain the loop taut. The wires are now placed within their protecting glass tube, the lower end of which is open and of such dimensions that the rod suspended from the resistance wire can just pass through. Still keeping the thermometer vertical and applying a suitable blowpipe flame, the lower end of the tube is closed by fusing it to the glass rod. When cold, the superfluous glass is cut off and the end rounded in the flame. The Pt filament is thus securely anchored to the bottom of the tube. E. G.

**1376.** *The Volta-Effect in Vacuo and in Highly Rarefied Gas.* **E. Perucca.** (N. Cimento, 23. pp. 105–131, Jan., 1922. Comptes Rendus, 173. pp. 551–554, Oct. 13, 1921.)—After a brief introduction the subject is dealt with under the following heads: The experimental proof and the apparatus required to obtain it; production and measurement of the vacuum; production of fresh surfaces; experiments in various gases; measurements and results obtained from them; discussion of the results. The following general conclusions are arrived at:—The Volta-effect exists in vacuo in the absence of traces of external gas; 0·17 volt is found with Zn/Hg couple (Hg negative); 0·26 volt with Sb/Hg couple (Hg positive); 0·22 volt with Cd/Hg couple (Hg negative), but less well-determined. When a very small trace of various dry gases or water-vapour is introduced, a modification of the Volta-effect takes place characteristic of the metals being examined and of the nature of the gas. The influence of very dry oxygen upon the Volta-effect obtained with the couples Zn/Hg, Cd/Hg is most marked, while this is not the case with water-vapour. The variations due to the introduction of gas are definite; slight modifications of a reversible nature are, however, observed with the couple Cd/Hg in air. This does not exclude the probability of variation in the initial Volta-effect due to the molecular arrangement of the fresh surfaces, independently of the residual gas. The experiments of Coehn and Lotz have a scope analogous to those here described, but deal with electrification by friction. These authors found a triboelectric effect *in vacuo* in the absence of traces of foreign gases. A. E. G.

**1377.** *Effect of Gases on the Contact Difference of Potential between Metals at Different Temperatures.* **O. W. Richardson** and **F. S. Robertson.** (Phil. Mag. 43. pp. 162–174, Jan., 1922.)—The present paper deals with some observations of the curves connecting thermionic electron current and applied p.d. (characteristic curves) for the case of a straight hot wire and a coaxial metal cylinder when small known pressures of gases, principally hydrogen, are present. The currents dealt with were rather small, being of the order $7 \times 10^{-8}$ amp., and approximate saturation was attained under the experimental conditions with accelerating potentials of the order of a volt. Attention has been directed chiefly to the region in which the curves approach the voltage axis. In this region the shapes of the curves are determined by the distribution of velocity among the emitted electrons, by the geometry of the electrons, and the fall of potential along the hot wire. Whilst these factors were not exactly identical in all the comparative experiments, it is believed that the effects of variation in them are practically negligible, with the result that the shapes of the different curves under comparison are invariable. This is true not only for the curves taken under high vacuum conditions, but also for those taken when small quantities of hydrogen were admitted. Whilst in general the curves are of the same shape, they are not in identical positions, but those obtained in the presence of hydrogen are displaced along the voltage axis as compared with those obtained in a vacuum. Inasmuch as for a given maximum or saturation current the shapes of the curves are the same, it is reasonable to infer that the infra-saturation currents will be sensibly the same function of the true voltage between the electrodes. The voltage plotted in the diagrams is the voltage between the central point of the hot wire and the surrounding cylinder as read on a voltmeter which in effect is inserted between these points. This differs from the voltage by an amount equal to the contact p.d. between the surfaces plus an effect arising from the drop of potential due to the heating current down the wire. With the arrangements used, the last effect is believed to have been sensibly the same in all the experiments; so that the displacement of the curves along the voltage axis should be a measure of the change which took place in the contact potential difference between the hot wire and the surrounding cylinder under the conditions investigated. The actual experimental arrangements adopted were for the most part those common in thermionic work. For the production and maintenance of a high vacuum a mercury vapour pump, backed by an oil box pump in series with a Geryck piston pump, was used, and this could be supplemented when desirable or convenient by a liquid-air cooled charcoal attachment. The tubes were mounted so that a vacuum furnace could be placed over them when desired, so as to get the gas out of the tube walls and electrodes. When desired pure hydrogen could be admitted by gently heating an attached palladium tube with a Bunsen burner, and the pressure read off on a McLeod gauge. The pressures of hydrogen used were all so small that they did not affect the shapes of the curves to any ascertainable extent by interference of the gas molecules with the motions of the electrons. The problem of maintaining a wire accurately at a constant temperature in presence of varying amounts of gas is one of great difficulty. With platinum, the effect of absorbed hydrogen on the resistance, and the cooling effect of the hydrogen atmosphere, vitiate the resistance method of holding the temperature constant. It is doubtful whether the methods of optical pyrometry as applied to thin filaments are sensitive enough for this purpose. Another difficulty arises from the very considerable effect of hydrogen in changing the emission constants of the metal. If a standard temperature is set up for some particular pressure, it may be that on changing to another pressure the emission will be so high that the shape of the characteristics is changed owing to the effect of the self-repulsion of the electrons, or, on the other hand, it may be so low that the instruments available are not sensitive enough to make measurements of it. Rapidity of operation is probably the most important factor for success in such experiments. Mainly for these reasons the procedure adopted in all cases, after each change in conditions, was to regulate the temperature of the wire so that the saturation current was maintained at approximately its original value, which could be done rapidly by a regulating rheostat. The comparisons made are not between wires maintained at a given temperature with different gas pressures, but between wires at such various temperatures as will maintain the thermionic current constant. These various temperatures are in general a function both of the original high-vacuum temperature and of the pressure of the admitted gas. Experiments with Pt are described and accompanied by a theoretical discussion of the platinum displacements. For a given increment in pressure, the voltage displacements are greater when the pressure is low. The displacements on reducing the pressure were generally somewhat smaller than those obtained when the pressure was increased between the same limits. This is probably due to the time required to attain equilibrium between the gas and the metal. A large number of experiments have been made with tungsten filaments and copper anodes, using saturation currents of the same order as before, namely $10^{-7}$ amp. For some reason at present unknown it was found more difficult to get consistent results with tungsten than with Pt. It is probable, however, that the main factor is the superior chemical activity of W and Cu as compared with Pt. Mercury vapour was found not to affect the contact potential between hot tungsten and cold copper. This is in agreement with a previous observation that the electron emission from tungsten is not affected by mercury vapour. It is questionable whether small quantities of hydrogen have any effect or not. An oxidised filament is electropositive by about 0·6 volt as compared with a clear filament at these temperatures. When the filaments were oxidised the currents were found to be difficult to saturate. Numerous curves are shown in the paper. **H. H. Ho.**

**1378.** *Electric Dipole in Liquid Dielectrics.* **J. Herweg and W. Pötzsch.** (Zeits. f. Physik, 8. 1. pp. 1–12, 1921.)—In a former paper [Abs. 715 (1921)] one of the authors has calculated on the basis of Debye's "dipole theory" that the dielectric constant of a liquid dielectric (containing dipoles) must diminish under the action of electric fields. The change is given by the expression

$$\Delta e = \frac{4\pi N m^4}{15 k^3 T^3} \cdot \frac{E^2}{(1-\theta)^4}.$$

The authors now subject this theoretical expression to experimental test. They determine the dipole-moment of the ether molecule, and obtain a mean uncorrected value of $12{\cdot}46 \times 10^{-19}$. This value is subject to a correction, depending on the adiabatic heating of the ether in the experiment. This adiabatic correction is determined and the corrected mean value of the dipole-moment found to be $12{\cdot}0 \times 10^{-19}$.

The relation for $\Delta e$, given above, is proved experimentally for different values of N and T (where N is the number of dipoles, or molecules per cm.$^3$ and T the abs. temperature). **A. B. W.**

**1379.** *Effects of Distributed Capacity between Inductance Coils and the Ground.* **G. Breit.** (Bureau of Standards, Bull. 17. pp. 521–527 [Sci. Papers No. 427], 1922.)—The effective capacity of an inductance coil depends in general both on the capacities existing between parts of the coil itself and on the capacities existing between parts of the coil and the ground.

On account of the importance of capacity effects in h.f. inductance coils, careful studies of these effects, both theoretical and experimental, have been made. An interesting result which has been found is that one effect seems to depend primarily on the capacity of the coil to earth. This effect is observed when two condensers in series are connected across the terminals of the inductance coil and the common terminal of the two condensers is earthed. If the inductance coil possesses capacity to earth, the familiar criterion for resonance in the system, computed from the known values of the capacities of the two condensers, will not obtain.

If both condensers are variable, and the system is adjusted for resonance by successively assigning arbitrary values for the setting of one condenser, and then tuning with the other condenser, it would be expected from elementary considerations, neglecting the effects of distributed capacity, that the successive resonance values of the capacity of the two condensers in series, determined as the product of their capacities divided by their sum, would be constant. On account of the distributed capacities, this simple relation does not hold. It is found, however, that under the conditions above mentioned, with the common terminal earthed, the capacity of the two condensers in series determined as the product of their capacities divided by their sum, is linearly related to the reciprocal of the sum of their capacities; that is, $C_1C_2/(C_1 + C_2)$ is a linear function of $1/(C_1 + C_2)$. This relation has been verified both mathematically and experimentally.

The condensers used in making accurate wireless measurements are provided with metal shields and one terminal is connected to the shield. The shield is usually earthed. If two shielded condensers are connected in series so that an earthed common connection is made to the two terminals which are connected to the shield, and if the unshielded terminals are connected to an inductance coil, the relation above mentioned will obtain. This relation is therefore particularly useful in making accurate measurements at such high frequencies. L. H. W.

**1380.** *Use of Anderson's Bridge for the Measurement of the Variations of the Capacity and Effective Resistance of a Condenser with Frequency.* **S. Butterworth.** (Phys. Soc., Proc. 34. pp. 1–8, Dec., 1921.)—An analysis of the effect of residuals and earth capacities in Anderson's inductance-capacity bridge is made, and it is shown that if balances are obtained (*a*) by balancing the bridge with *direct* currents, (*b*) by making the alternating-current adjustments by means of a small series resistance ($s'$) and parallel condenser ($C'$) in the condenser arm, then the changes required in $s'$ and $C'$ to hold the balance at different frequencies are equal and opposite to the variations of the effective (series) resistance and capacity of the condenser with frequency. The method is illustrated by results obtained with a condenser of capacity $0\cdot 5\mu$F, and details are given showing how the chief experimental trouble, viz. drift in d.c. balance owing to temperature variations, may be overcome. AUTHOR.

**1381.** *Earth Capacity Effects in Alternating-Current Bridges.* **S. Butterworth.** (Phys. Soc., Proc. 34. pp. 8–15; Disc., 15–16, Dec., 1921.)—It is shown that an earth capacity acting at any point in the arm of a bridge may be replaced by two earth-impedances acting at the ends of the arm together with an impedance in series with the arm. By integration the result is extended to small distributed capacities. Two methods are given for the elimination of the error due to the end impedances. Complete elimination can only be obtained by the use of shields connected to the ends of the bridge arm. AUTHOR.

**1382.** *Electrical Conduction in Solid, Electrically Badly-conducting Bodies; Experiments with Mercuric Iodide.* **F. Kaempf.** (Ann. d. Physik, 66. 7. pp. 463–496, Feb. 24, 1922.)—In an earlier paper [see Abs. 1430 (1912)] the author has shown that with selenium preparations under definite conditions, current–voltage curves can be obtained, which possess the appearance of those found for saturation currents in gases. For this purpose very thin red translucent layers of Se (after transformation) are necessary, which exhibit a high specific resistance in comparison with compact selenium. Gripenberg's work in this field is quoted [see Abs. 920 (1912)]. The possibility of obtaining such a current–voltage procedure as with saturation currents in gases was traced in the earlier paper to processes at the kathode, but a proof could not be submitted at the time. Various consequences, which could be deduced from this hypothesis, were tested on selenium, but the results were insufficient for publication. Recently, however, red mercuric iodide, whose sensitiveness to light has been established by Volmer, was found to be much more suitable than Se for this investigation, and the present paper is the outcome of experiments with this substance. The preparation and general properties of mercuric iodide are described at great length, following which comes an exhaustive account of the experimental methods adopted and of the apparatus employed. The dependence of the resistance on the strength of the incident light is discussed with experimental data, and succeeded by a lengthy theoretical examination of the electronic theory of metallic conduction. It was established that on current passage the conductivity continually decreases with growing current strength, so that the current–voltage curve has an appearance similar to that given by dense gases for approximate current saturation. If the conductivity is varied at both electrodes by varying strong illumination, then with increasing voltage, sharply-rising unipolar conduction is obtained. From the connection between current strength and direction and the ratio of the conductivity at the anode and kathode, it follows that the current is carried essentially by negative particles (electrons). Special section measurements showed that both at the kathode as at the anode a transition resistance between layer and electrode arises; the kathode resistance increases greatly, while that at the anode is somewhat less strong with the current density. The low dark conductivity observed is mainly of an electrolytic nature and perhaps is occasioned by impurities. It is shown theoretically that on the assumptions of the electronic theory, taking into consideration diffusion at the boundary layer-metal, a transition resistance occurs. From the thickness of this boundary layer the mobility of the electrons in the mercuric iodide is calculated at about 2·9 cm./sec. per volt/cm. From considerations of a more qualitative character, it is shown that the transition resistance at the kathode must increase with growing current density, a result which has been confirmed by experiment. The behaviour at the anode requires still further investigation. It has been demonstrated that with electrodes of varying size, unipolar effects must occur, on account of the dependence of the layer resistance on the current density. H. H. Ho.

**1383.** *Dielectric Constants of Gases and Vapours by Valve Methods.* **Bedeau.** (Comptes Rendus, 174. pp. 380–381, Feb. 6, 1922.)—A method is described for measuring the dielectric constants of gases and vapours. The method makes use of two continuous-wave generators, A and B, one being used as a heterodyne. The two are adjusted for the same wave-length (700 m.), and when the capacity of A is altered by $\Delta C$, the note heard has a frequency $\Delta N = \frac{1}{2}N.\Delta C/C$, where N is the original frequency. If the initial setting is made when the condenser C is evacuated, the introduction of a gas into the chamber containing C produces a variation $\Delta C = (K - 1)C$, and hence the frequency of the note heard in the telephones is $\Delta N = \frac{1}{2}N(K - 1)$, K being the dielectric constant of the gas. If N is accurately known, K is given from the measurement of $\Delta N$. The author, however, in the experiments here described has measured directly the values of $\Delta C$ and C. Hence C must be large in order that $\Delta C$ may have a sufficiently large value to be measured exactly. Details of the actual apparatus and method are given. Using dry air at 15° C. and 75·5 cm. pressure, the value of K obtained was 1·000586, the probable error being 1 %. A. W.

**1384.** *Sensitivity of Ballistic Galvanometers.* **E. Wilson.** (Phys. Soc., Proc. 34. pp. 55–64; Disc., 64–65, Feb. 15, 1922.)—Effects due to excessive damping in moving-coil galvanometers are reduced by opening the galvanometer circuit after an interval of time which is small compared with the period of the instrument. Employing a constant time-interval of closing the circuit, the total resistance of which is kept constant, the quantity of electricity discharged in the circuit is proportional to the first throw, and this being increased by the procedure suggested, the method is one affording greater sensitivity. The mathematical theory of the method is developed and shown to agree with the results of experiments in which the time of closing a secondary circuit was determined either by a weight falling with uniform velocity, and successively interrupting the primary and secondary circuits of a mutual inductance, or by a freely falling weight released by the operation of the primary switch. The method has been applied to the magnetic testing of iron in extremely weak fields of the order $H = 7 \times 10^{-6}$ c.g.s. units. The results so far obtained appear to indicate that the permeability of transformer iron stampings decreases from 145 to 137 when the field decreases from $17 \times 10^{-6}$ to $6{\cdot}84 \times 10^{-6}$ c.g.s. units. J. S. G. T.

**1385.** *Ballistic Galvanometer Theory.* **H. Chaumat.** (Comptes Rendus, 174. pp. 32–35, Jan. 3, 1922. Rev. Gén. d'Él. 11. pp. 115–116, Jan. 28, and pp. 155–156, Feb. 4, 1922.)—Formulæ are deduced for the angular deflection under different conditions of damping, given the same initial angular velocity of the moving coil. These formulæ give the angular deflection in terms of the damping for the critical resistance of the circuit, and in some respects are preferable to the classic formulæ. A. W.

**1386.** *Theory of the Grassot Fluxmeter.* **R. B. Burrowes.** (Electrician, 88. pp. 122–123, Feb. 3, 1922.)—The author shows that the scale of this instrument is uniform, the deflection being proportional to the change of linkage in the test circuit, but not dependent on the rate of change. The energy used, however, due to resistance, is proportional to the rate of change. When the coil returns to zero from its deflected position, the same quantity of electricity passes round the circuit, but against a smaller e.m.f. The energy given to the circuit as heat in this way has its equivalent in the potential energy of the twisted fibre in the deflected position. If the coil were weightless its movement would synchronise with the change of flux linkage. In the other extreme when the whole flux-change occurs before the coil moves it is shown that the throw would be proportional to the initial angular velocity, just as in the ballistic galvanometer where the control is considered wholly torsional. Under the same conditions, the time of throw is independent of the amplitude, the magnitude of the throw is independent of resistance and reactance, and the energy absorbed is proportional to the square of the throw. L. L.

**1387.** *Automatic Voltage Regulator.* **F. G. H. Lewis.** (Phys. Soc., Proc. 34. pp. 17–20; Disc., 20–21, Dec., 1921.)—Of the Wheatstone bridge form with tungsten lamps in the opposite arms. L. H. W.

**1388.** *Modified Wulf's Apparatus for the Measurement of Penetrating Radiations.* **W. Kolhörster.** (Zeits. f. Physik, 5. 1. pp. 107–110, 1921.)—A description is given of a robust portable form of Wulf's string electrometer for use in aeronautical work in balloons at great altitudes. The design embraces as its main features robustness, portability, independence of atmospheric pressure and temperature changes, etc. A. B. W.

**1389.** *Portable Vacuum Thermopile.* **W. W. Coblentz.** (Optical Soc. of America, J. 5. pp. 356–362, July, 1921.)—A vacuum thermopile mounting which is rendered portable by attaching a calcium evacuator permanently to the radiometer container, thus dispensing with an air-pump. L. H. W.

## ALTERNATING CURRENTS AND MAGNETISM.

**1390.** *New Method for Measuring the Susceptibility of a Liquid.* **G. Athanasiadis.** (Ann. d. Physik, 66. 6. pp. 415–426, Feb. 7, 1922.)—A dropping funnel is fixed vertically with its orifice at a point immediately above the uniform horizontal magnetic field between the poles of a Du Bois electromagnet. If a para- or dia-magnetic liquid is issuing in drops from the tube, then on exciting the field they will experience a mechanical force, being situate in a non-uniform field, and consequently the size of the drops will be modified. It is shown that the susceptibility ($k$) of the liquid is $d(N_0 - N)/N_0 \,.\, g \,.\, H \,.\, dH/dx$. $N_0$ is the number of drops formed when a given volume runs out and the magnet is not excited, N is the number formed from the same volume when the field is on, $d$ is the density of the liquid, H the value of the field, and $dH/dx$ the variation of the field in the vertical direction at the middle of the drop. The method has been used to measure the susceptibility of water ($-0{\cdot}727 \times 10^{-6}$), and a large number of other liquids The results are compared in a table with those obtained by other observers, and are of the same order of magnitude. The temperature, however, at the time of the present observations was about 30° C., and it is probable that the measurements of the other investigators were made at a somewhat lower temperature. L. L.

**1391.** *Magneto-Chemical Investigation of Constitutions in Inorganic Chemistry.* **P. Pascal.** (Comptes Rendus, 174. pp. 457–460, Feb. 13, 1922.)—The magnetic susceptibilities of phosphorus compounds are considered in the manner previously used for sulphur compounds [Abs. 1019 (1922)]. The results obtained show that in all incompletely saturated derivatives, the diamagnetism of phosphorus or of oxyphosphorus groupings is greatly attenuated, in conformity with the general rule formulated earlier. In these unsaturated derivatives, phosphorus and oxyphosphorus radicals exhibit constant magnetic individuality, the values for P, $PO_2$, and $PO_3$ being $-100 \times 10^{-7}$, $-185 \times 10^{-7}$, and $-237 \times 10^{-7}$ respectively, which form an arithmetical progression with a common difference sensibly equal to the atomic susceptibility of the oxygen of alcohols or etheric oxides. It is therefore assumed that a phosphorus atom with a constant degree of saturation occurs in phosphines, hypophosphites, metallic phosphites, and neutral phosphorus ethers, the oxygen serving only to link the phosphorus atom to the metal, hydrogen or hydrocarbon radicals of the rest of the molecule. Thus, to hypophosphorus and phosphorus acids the structures $PH(OH)_2$ and $P(OH)_3$ must be ascribed.

For phosphorus and its oxygen-containing radicals in saturated derivatives the values are $-263 \times 10^{-7}$, $-220 \times 10^{-7}$, $-313 \times 10^{-7}$, and $-364 \times 10^{-7}$ for P, PO, $PO_3$, and $PO_4$ respectively. The last three form an incomplete arithmetical progression, the common difference being as before. T. H. P.

**1392.** *Physical Theory of the Earth's Magnetic Field.* **A. Nippoldt.** (Terrest. Magn. 26. pp. 99–111, Sept., 1921.)—The principal part of the earth's magnetic field consists of a non-homogeneous magnetisation of the earth's crust down to a depth of about 20 km. In addition, there may exist, for the earth's nucleus, a magnetic field symmetrical both about the earth's axis of rotation and the equatorial plane, which may have arisen in the same manner as has the sun's general magnetic field. Besides these two fields there may be, in general, a third, interplanetary, field, whose axis is perpendicular to the plane of the ecliptic, and which may be caused by the sun's electric radiation. AUTHOR.

## RADIOGRAPHY AND ELECTROPHYSIOLOGY.

**1393.** *Effects of Scattered X-Rays in Radiography.* **R. B. Wilsey.** (Eastman Kodak Co.'s Lab. Comm. No. 125. Frank. Inst., J. 193. pp. 255–256, Feb., 1922.)—The effects of scattered X-rays upon radiographic contrast and definition were investigated and also the improvement effected by reducing the intensity of scattered radiation and by the use of intensifying screens or by a reduction of the tube voltage. The loss of contrast due to scattered radiation was found to be much greater for portions of the subject at a distance from the film than for portions close to the film. Reduction of the intensity of scattered radiation by a diaphragm produces the greatest improvement in contrast and definition in those parts of the subject farthest from the film and gives a greater improvement than that effected by reducing the tube voltage from a 5-in. spark-gap to a 3-in. gap. Filters placed between the scattering material and the film gave no improvement in contrast. In the detection of faint differences in absorption the removal of scattered radiation gives results much superior to those of any other technique. The most satisfactory solution of the problem of scattered radiation appears to be the Potter-Bucky diaphragm. L. H. W.

**1394.** *Investigations of Transformer Rectifier Sets.* **M. A. Codd.** (Röntgen Soc., J. 18. pp. 27–42; Disc., 42–44, Jan., 1922.)—Certain suggestions are here advanced and details given of improvements in the design of transformer rectifier sets which should tend to bring them more to the level of the best kinds of coil apparatus. When a transformer set is compared with a large-size 16-in. coil by exposing pastilles, in each case using an alternative gap of 5 in. between points taking 5 milliamps. mean current, it is found that with the coil the pastille turned in 5 minutes, whereas with the transformer 6 minutes were needed. Two reasons for this discrepancy are suggested: (*a*) the difference in wave-form, of which the milliammeter does not take account, (*b*) the impulse ratio of the tube, i.e. the ratio of the voltage necessary to break down the initial resistance of the tube to the voltage necessary subsequently to keep it in action. Admitting the truth of this hypothesis, the conditions contingent on the use of the coil and transformer are considered. Various current wave-forms obtained are given, as are also diagrams showing experimental arrangements. It is shown that it is desirable to vary the angle of collection according to the current used and the state of hardness of the tube. This is best obtained by the use of spherical or kidney-shaped " pick-ups " of suitable diameter. These give almost ideal results for medium currents. When, however, very large currents are to be dealt with, such as in single-

flash conditions or with specially powerful apparatus or with apparatus for generating very high voltage for therapeutic work, the arc at the gaps between the segments and collector balls still persists for too long a time, and it is advisable to augment the rapidity of the break by other means. This is best done by a blower. These blowers, in conjunction with the ball "pick-ups," prove entirely satisfactory, but the blowers must be used judiciously. It is concluded that the auto-transformer, while more economical and convenient for manipulation, does not entirely justify the claims made for it. When a condenser is added to the circuit the curves obtained show that the condenser, besides inherently influencing the impulse-ratio, acts as a condenser, in the common form of the word, storing up the small peaks, inverse and inequalities, and giving them out in the correct direction and at the correct time through the tube. The capacity of the external tube circuit should be kept low, i.e. overhead leads, Coolidge controls, etc., should be as small as possible. The ball "pick-ups" should also be as small as possible, keeping in view efficient collection; because of this they may advantageously be kidney-shaped.
A. E. G.

**1395.** *Measurement of the Penetrative Power of X-Rays by Means of a New Radiochromometric Device.* **M. de Laroquette.** (Comptes Rendus, 174. pp. 604–607, Feb. 27, 1922.)—Whilst admitting the usefulness of the Benoist radiochromometer, the author states that this instrument is not very exact for hard rays; for example, with five instruments chosen at random, two gave readings of VIII B, two readings of VII B, and one a reading of VI B, with the same source. Below a certain voltage, about 70,000, it is difficult to obtain more than VIII B without filtration irrespective of the voltage and power of radiation. The author has therefore evolved an instrument which has two series of tints that may be obtained simultaneously with and without filtration of a known thickness of Al. The instrument is illustrated and described, and a comparative table with Benoist units given. The scale ranges from IV to XIV instead of from 3 to 12 as in the Benoist instrument.
B. J. L.

**1396.** *Notation of Curie Therapy (Radium Treatment).* **S. Laborde.** (Arch. d'Él. Médicale, 30. pp. 14–23, Jan., 1922.)—Errors and confusion arising with the present notation of therapeutic dosage are discussed. To determine with precision an application of radium or radium emanation it is necessary to consider the characteristics of the particular apparatus and the conditions of its use. We must know the form and dimensions of the apparatus, their number, the nature and thicknesses of the interposed filters, either primary or secondary, and their position and relations to the tissues. It is, however, sufficient to remember that all the technical arrangements which are able to assist in the exact reproduction of the application must be noted unless we are to have discrepancies.

Owing to the confusion which exists whilst the terms "milligramme hours" and "millicurie hours" are used sometimes as units of power and sometimes as units of energy, the therapeutist must not omit to indicate: (1) the weight of Ra metal in mgm. or the initial quantity of RaEm in millicuries. It is then known if we are dealing with a constant or decreasing radiation. (2) The duration of the application expressed in hours. (3) The total energy given in the course of the treatment, expressed for example in millicuries destroyed. The last factor, often designated as "dose" or "emitted dose," does not represent the actual transmitted dose, but varies with the thickness of the walls of the containing vessel, and should no longer be designated as the "absorbed dose," as it only expresses the dose within the container. B. J. L.

**1397.** *An Ionometer.* **Solomon.** (Arch. d'Él. Médicale, 29. pp. 357–365, Dec., 1921.)—An instrument designed to measure the energy emitted by an X-ray tube (or radium) utilising the well-known fact that such rays produce ionisation of the surrounding air, and discharge of a charged conductor. The ionisation current is proportional to the radiated energy, and as it has been shown the biological action of X-rays is proportional to the energy absorbed by the tissues, a measurement of the ionisation current gives a knowledge of the energy which will be absorbed by the living tissue and of the consequent effect. This apparatus consists of a needle which is displaced by variation of its electrical charge, the needle being mounted upon a carrier passing through an insulating bush. Movement of the needle is shown by means of an optical system which illuminates the needle from behind and projects a shadow of it upon a frosted glass window with a graduated scale in front. The needle is electrostatically charged by a small friction apparatus of amber and chamois actuated by a rotating handle in front of the apparatus. In order to discharge the needle, if desired, a small weakly-conducting button can be depressed to touch the needle-holder.

The above system can be utilised as a condenser by its being surrounded by air alone, or, in order to reduce the sensitiveness but to allow a more prolonged measurement to be taken, a condenser of much larger capacity is formed by the interior container isolated from the lead container (4 mm. thickness) which forms the case of the apparatus and is earthed. This Faraday pail can be cut out when desired. The exploring coil exposed to the radiation consists of a graphite rod within a graphite container, the use of graphite obviating the secondary radiations which would occur if a material of high atomic weight were used. Its small size allows it to be easily introduced into cavities for deep therapy. Connection between exploring coil and the instrument is made by a partly rigid and partly flexible connection.

The instrument is calibrated in terms of a unit R (the Röntgen), i.e. the ionisation produced in 1 sec. by 1 gm. of Ra at a distance of 20 mm. after filtration by 0·5 mm. of Pt. A relation 1000 R = 5 Holzknecht = Sabouraud tint B exists.

Detail instructions are then given of the use of this apparatus for measuring (1) intensity of radiation, (2) coefficient of transmission of a filter, (3) predetermination of time of deep radiation corresponding to any incident dose, (4) total incident dose, (5) relation of deep dose to incident dose, (6) actually applied deep dose, (7) value of a radium apparatus. B. J. L.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

**1398.** *High Pressure due to Adsorption, and the Density and Volume Relations of Charcoal.* **W. D. Harkins** and **D. T. Ewing.** (Am. Chem. Soc., J. 43. pp. 1787–1802, Aug., 1921. Chem. News, 123. pp. 344–347, Dec. 30, 1921; 124. pp. 23–24, Jan. 13, and pp. 31–35, Jan. 20, 1922.)—Evidence is given in favour of the hypothesis proposed earlier by the authors, which is that *the liquids which penetrate into charcoal are compressed by the action of a force, due to molecular attraction, which acts as a pressure of many thousand atmos.* In the earlier paper it was estimated that the pressure corresponded to twenty thousand atmospheres or more. The present paper indicates that it is the liquid in the micropores, and not that in the macropores which is compressed. On this basis the pressure would probably be considerably higher than the previous estimate, since at that time only the total pore volume was known and considered. Not only charcoal, but also all other porous substances, such as porous ceramic materials, and also very fine powders, should exert this compressive effect, but in general to a much smaller extent. The remarkable feature of the experiments listed is that they demonstrate the compression by direct measurements of the volume-changes in the liquids. Experiments on the internal pressure of liquids have not succeeded in demonstrating pressures higher than 72 atmos.

Ether, which is much more compressible than water, occupies a volume *in the charcoal* which is about 10 % less than that occupied by the amount of water which is, *outside the charcoal*, equal in volume to the ether. It seems probable that the water in the micropores is compressed by about 25 %, or even more, while the ether is compressed by about 40 %. It is evident that the liquids in the macropores, of the order of $1 \cdot 2 \times 10^{-3}$ cm. in diameter, are not compressed sufficiently to produce any noticeable effect upon the volume.

The true volume relations in 1 $\text{cm.}^3$ of a characteristic coconut-shell may be estimated as: volume of micropores, $0 \cdot 28$ $\text{cm.}^3$; of macropores, $0 \cdot 18$ $\text{cm.}^3$; of carbon, $0 \cdot 54$; which gives a density of about $1 \cdot 60$ for the carbon. The density of the lumps of such a charcoal is about $0 \cdot 868$, though this lump or "block" density is as high as $1 \cdot 49$ for a charcoal made from anthracite coal, and as low as $0 \cdot 52$ for a wood charcoal.

L. H. W.

**1399.** *Thermal Evolution of Gases Absorbed by Charcoals and Carbonised Lignites.* **S. McLean.** (Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 73–84, 1921.)—Measurements were made of the heat evolved during the adsorption of air, oxygen, nitrogen, and $CO_2$ by different samples of charcoal and carbonised lignites. Of the gases examined, oxygen was found to develop the largest amount of heat for a given volume adsorbed. This was found to be due to chemical action resulting in the formation of both $CO_2$ and CO. The largest amount of heat evolved per unit weight of adsorbent was obtained with $CO_2$ which, of the gases tried, was adsorbed in the largest quantity. In this case, the heat developed is not accounted for by the latent heat of vaporisation of the amount of gas adsorbed, showing that some process other than condensation is taking place. The coarser kinds of charcoal adsorb more oxygen and form $CO_2$ more readily than the more finely-divided charcoal. J. N. P.

**1400.** *Prehensility: a Factor of Gaseous Adsorption.* **H. Briggs.** (Roy. Soc. Edinburgh, Proc. 42. 1. pp. 26–33, 1921–1922.)—Prehensility is defined as the slope at the origin of an adsorption isotherm. A method of measuring prehensility is described, and results are given for various adsorbents at liquid air temperature. It is shown that from the prehensility the evacuating power of a substance may be calculated. In evacuating any given volume, the weight of charcoal required to yield a required reduction of pressure may be computed. The degree of vacuum obtained in a Dewar liquid-air container is discussed. The plumstone charcoal used by the author had a higher evacuating power than coconut charcoal. L. H. W.

**1401.** *The Periodic System and the Theory of Radio-Active Degradation.* **F. Kirchhof.** (Zeits. phys. Chem. 94. pp. 257–262, April 20, 1920.)—The author considers most of the elements to be mixtures of isotopes. Thorium probably passes finally into Cr, Mo, W. In the case of the more stable elements the atomic weight A, the Moseley number M, and I, the number of electrons, are thus related: $A = 2(M + I)$. H. B.

**1402.** *Methods of Concentrating the Lighter Isotopes of Iodine.* **E. Kohlweiler.** (Zeits. phys. Chem. 94. pp. 95–125, July 13, 1920.)—The anomalous positions of iodine and tellurium in the periodic table suggest that the lighter isotopes predominate in iodine and the heavier isotopes in tellurium. The author attempts to separate iodine into its isotopes (probably 5, mass 122, 124, 126, 128, 130) by two methods. With the mean mass of 126·92 (the accepted atomic weight) the extreme deviations would amount to $-3 \cdot 88$ and $+2 \cdot 43$ %. Diffusion experiments were made by heating iodine in a flask, and passing the vapour through an inclined glass cylinder, 30 cm. long, 64 mm. in diam., set with 16 membranes of clay in series, at right angles to the cylindrical axis, and then through two flasks charged with carbon disulphide, separately joined to a pump. The flask and cylinder were electrically heated, the latter by a wire coil; all the cylinders flew into pieces until they were coated with sodium silicate; the membranes were cemented in with a paste of barium sulphate and sodium silicate. Altogether 768 diffusion experiments were made, but only 4·5 gm. of iodine was passed through the apparatus. This iodine was then submitted to vapour density determinations (Dumas) after repeated sublimations, fractionations, and recrystallisations. The lightest iodine finally obtained differed by 2·07 % from the mean, yielding an atomic weight of 128·22. H. B.

**1403.** *Separation of Isotopes. Theory of Resolution of Isotopic Mixtures by Diffusion, etc. Separation of Isotopes of Mercury by Evaporation in Vacuo.* **R. S. Mulliken** and **W. D. Harkins.** (Am. Chem. Soc., J. 44. pp. 37–65, Jan., 1922.)—The various phenomena of diffusion and effusion in gases are discussed in connection with the separation of isotopes. (*a*) It is shown that for the processes of molecular diffusion through a porous membrane, molecular effusion, and non-equilibrium evaporation, the relative rates of escape of isotopes are proportional to their respective "mol-fractions" and inversely proportional to the square roots of their molecular weights. In all the above processes the molecules move independently. As collisions between molecules become more frequent, non-equilibrium evaporation passes into ordinary distillation, and molecular diffusion passes into capillary transpiration or mass motion. In either case, practically no separation of isotopes occurs. (*b*) If a gaseous mixture of isotopes diffuses into another gas, with no convective mixing, the diffusion coefficients of any two isotopes are in the ratio $(x_1/x_2) \sqrt[c]{(M_2/M_1)}$, where $c$ is a variable quantity usually in the neighbourhood of 1 or 2. The theory is complicated, but suggests a higher rate of separation than for molecular diffusion and evaporation, for which $c$ is always 2. (*c*) Another possible method is that of "initial diffusion," which would take advantage of the fact that the front rank of molecules diffusing into a gas or a vacuum should be enriched in the lighter isotopes.

The theory of non-equilibrium evaporation is discussed, and experimental work on the partial separation of mercury into isotopes by non-equilibrium evaporation is described. The experimental results are in good agreement with the theory developed in this paper. A. B. W.

**1404.** *Elongation of Single Crystals of Tungsten.* **H. Schönborn.** (Zeits. f. Physik, 8. 6. pp. 377–381, 1922.)—Tungsten wires, 70 to 90 μ in diameter, from the Pintsch works, are horizontally stretched between the limbs of a horseshoe frame, to the end faces of which they are attached, and loaded in the middle as in Kohlrausch's determination of the modulus of elasticity. The sag of the wire is observed by a telescope. With loads corresponding to a maximum of 70 kg./mm.² the wire immediately returned to its original position on removing the load. With greater loads the vertical displacement $dh$, observed for an hour, followed the rule $dh/dt = Ac^{RB}$, where R is the tension on the wire and A and B are constants. There was no elastic after-effect, and the logarithmic curves were straight lines; but the absolute values for different wires differed, probably because the crystal axis and wire axis may not quite coincide. The ultimate strength of the wires was raised by the test, from 108 to 125 kg./mm.² referred to the initial cross-section. It is concluded that in the single crystals of tungsten the rate of flow increases experimentally with the stress and that Hooke's law holds beyond the elastic limit.

H. B.

**1405.** *Season-Cracking of Brass and other Copper Alloys.* **H. Moore, S. Beckinsale,** and **C. E. Mallinson.** (Inst. of Metals, J. 25. pp. 85–125; Disc. 126–152, 1921. Engineering, 112. pp. 262–264, Aug. 12; 297–299, Aug. 19; 327–331, Aug. 26, 1921.—Abstract.)—Gives the results of investigations of season-cracking of copper alloys including the cause, the detection of liability to fail in this way, the mechanism of the process by which the cracks form and develop, the effects of variations in composition, structure, and physical properties such as hardness, and the methods of prevention of season-cracking. The work was carried out on spun vessels, cartridge cases, rods, tubes, and small studs. The more important conclusions, some of which confirm the work of others, are as follows:—Season-cracking occurs in a great variety of industrial brasses, differing widely in composition, degree of purity, microstructure, and physical properties. It occurs only in material which is maintained in a state of stress, either by external constraint or, more commonly, by internal stress. Corrosion of the surface and sometimes of the walls of the cracks is frequently associated with season-cracking, but corrosion effects are not always visible. It may occur in brass coated with continuous protective layers such as lacquer; nickel plating is probably completely effective in preventing it, if a sufficient and continuous coating of Ni is secured. Highly stressed articles, capable of developing season-cracks in certain conditions, may be kept for years in reasonably pure atmospheres without showing any sign of cracking. Some agency additional to the presence of internal stress appears to be necessary for the development of season-cracks; surface defects which might localise stress and working or other imposed stresses additional to the initial stress, do not appear to contribute to their development to any important extent. Corrosion does not necessarily favour the development of cracks in stressed brass; very severe corrosion and pitting caused by the prolonged action of various acids and other corrosive agencies had no cracking effect on stressed brass, liable to develop season-cracks in other circumstances. Mercury, ammonia, and ammonium salts readily produce cracks in brass which is sufficiently stressed in tension. Season-cracks almost invariably follow an intercrystalline path. They occasionally cut through a crystal when the path round it is much longer, but resume their intercrystalline path on the other side. The intercrystalline nature of the cracks is a most marked and characteristic feature of season-cracks. The cracks produced by mercury or by ammonia in stressed brass are of the same intercrystalline type as season-cracks. The investigation of certain examples of rapid season-cracking indicated ammonium salts, acting on stressed brass as the cause of the cracking and ammonia was detected in a water extract of slightly corroded fractures caused by season-cracking in brass corroded by atmospheric action only. The presence of small amounts of ammonia in the atmosphere in which the brass was stored was suspected, and it is probable that traces of ammonia in the atmosphere are an important agency and possibly the main agency inducing season-cracking of stressed brass. Ammonia appears to have a specific and selective action upon the intercrystalline material of brass, weakening it sufficiently to cause cracking if in tension. Mercury has a similar intercrystalline weakening effect. Season-cracks and those caused by mercury and ammonia always begin in surface layers which are in tension. The greater the degree of hardening by cold work, the less is the brass affected by the intercrystalline weakening action of ammonia or mercury, although it is probable that weakening may occur whatever the hardness of the brass. It is probable that the behaviour of a copper alloy submitted to the combined effect of tension and of ammonia or mercury is a reliable index of its liability to fail by season-cracking. Liability to the development of season-cracks appears to diminish as the zinc content of brass is reduced. It is held that copper and copper-zinc alloys containing less than 10 % Zn are unlikely to fail by the development of season-cracks in service.

It is considered that this study of season-cracking and of the action of mercury and ammonia on stressed brass affords strong support to the hypothesis of an intercrystalline material differing essentially in its properties from the crystals themselves. It does not appear to be necessary to ascribe peculiar properties to the intercrystalline substance in order to explain the phenomena of season-cracking, and the authors are unable to find in the results of their work any evidence indicating that season-cracking is the result of viscous flow of the intercrystalline cement. The undoubtedly intercrystalline character of the season-cracks in brass appears to be fully explained by the selective weakening action of a chemical substance on the intercrystalline material. C. O. B.

**1406.** *Action of Reducing Gases on Heated Copper.* **H. Moore** and **S. Beckinsale.** (Inst. of Metals, J. 25. pp. 219–240; Disc., 241–258, 1921. Engineering, 111. pp. 729–732, June 10, 1921.)—The injury caused to copper by heating it in a reducing atmosphere was investigated by submitting the heated metal to tensile tests. These tests opened out the very fine cracks formed in the injured metal, as well as indicating a lowered tensile strength and ductility. It was found that the injurious effect of reducing gases on heated copper is the result of their interaction with the cuprous oxide which is always present in commercial copper. A markedly injurious effect is produced even when the oxygen does not exceed 0·026 %. The solubility of gases in copper at high temperatures permits of their diffusion into the metal, hydrogen diffusing much more rapidly than CO, while coal gas is intermediate between the two, though its weakening effect seems to be greater than either. In copper containing 0·07 % O, the effect of reducing gases begins to be serious at about 600° C. The lower the oxygen content, the higher the temperature required to cause injury, while the higher the temperature the more rapid is the action. Copper containing a small quantity of a reducing agent is free from oxide inclusions, and is not affected injuriously by heating in a reducing atmosphere. A method of preparing pure copper free from oxide is described. J. L. H.

**1407.** *Recrystallisation of Aluminium on Heating.* **H. C. H. Carpenter** and **[Miss] C. F. Elam.** (Inst. of Metals, J. 25. pp. 259–280; Disc., 281–307, 1921. Engineering, 111, pp. 302–307, March 11, 1921.)—Deals with the stages of recrystallisation of Al on heating and is illustrated by 38 photomicrographs. The purest commercial aluminium obtainable was used, containing 99·6 % Al, and the structure examined in the original casting 4¾ in. thick and after rolling to 2¾, 1, ½, ¼, and ⅛ in. respectively. The metal was rolled from 425° C. but was not reheated during the rolling, which resulted in the rolling being finished in the cold-rolled condition. The original casting shows the typical polygonal structure and successive rolling shows elongation of the crystals until in the final sheet the crystals' boundaries are so close together as to give the appearance merely of a number of parallel lines running in the direction of rolling. This indicates that the statement that Al loses its crystalline structure and becomes completely amorphous on working is incorrect. Experiments are described in which the rolled sheets were heated to temperatures varying from 200° to 600° C. for varying times, followed by examination of the structure. It is shown that there are three distinct types of structure produced, which correspond to different steps in the passage from the work-hardened amorphous crystalline complex to the fully softened crystalline sheet. They may be classified as follows: Type I is characteristic of metal heated for long periods at 220° C. and for short periods at 250°–300° C. It is the first visible structural change and is characterised by the general tarnishing of the surface, a granular structure and a blurring of the original boundaries of the flattened crystals. Type II is the birth of new crystals in the old boundaries. These always appear white in contrast with the tarnished unreoriented crystals. Characteristic of this type is the presence of new and old crystals in the same specimen, as obtained during the early stages of crystallisation at 250° and 300° C. Type III is the structure finally obtained after heating to structural equilibrium at a given temperature. Of this type there are two distinct forms depending on the temperature at which they are produced. One, produced at 250°–300°, shows the crystals to be very much elongated in the original direction of rolling; in the second, produced at 450°–600°, the crystals approximate more nearly to the equiaxed condition, though they still show a slight elongation in the direction of rolling.

*Birth of Crystals in Strained Metals.*—A note is added to the paper, on the birth of crystals in strained metals and alloys, for which samples of Al-Zn alloy and 70 : 30 brass have been examined. The results obtained confirm those obtained with Al sheet, that recrystallisation commences in the boundaries of the distorted crystals, and also show that recrystallisation may commence in twin boundaries [see Abs. 1170 (1921)].

C. O. B.

**1408.** *Röntgen Spectra of Iron and Steel.* **A. Westgren.** (Iron and Steel Inst., J. 103. pp. 303–325; Disc., 326–337, 1921. Engineering, 111. pp. 727–728, June 10, and pp. 757–759, June 17, 1921.)—The author discusses the theory of X-ray crystal investigation, with special reference to the method devised by Debye and Scherrer and by Hull, for the study of agglomerations of small crystals. He then describes an apparatus used in the investigation of iron and the results obtained with it. (A) *Results obtained at room temperatures: Pure iron.*—In agreement with Hull, the author finds that pure iron at ordinary temperatures ($\alpha$ ferrite) exists in the form of body-centred cubes. *Austenitic Steels.*—Steels containing 25 % Ni and 12 % Mn quenched from 1000° C. were examined. Such steels are in the austenitic condition, and were found to consist of face-centred cubes. (B) *Results obtained at high temperatures.*—The X-ray spectrum of pure iron was investigated at about 800° C. and 1000° C., at which temperatures it should exist in the $\beta$ and the $\gamma$ states respectively. In the case of the lower temperature it was found that the spectrum was identical with that of $\alpha$ iron. At the higher temperature the photograph showed only remote black spots, owing, doubtless to the fact that, at the high temperature, the crystals had grown very large. The points were sufficient for constructing a line spectrogram, which indicated that the iron consisted of face-centred cubes. From those facts the author deduces that the A3 point indicates an allotropic transformation, while the A2 point does not. The paper closes with a short discussion of the crystal structure of steel in the hardened state, the X-ray spectrum of which shows lines due to $\alpha$ iron and to iron carbide in the case of a high-speed steel.

J. L. H.

**1409.** *Properties of Nickel-Aluminium-Copper Alloys.* **A. A. Read** and **R. H. Greaves.** (Inst. of Metals, J. 26. pp. 57–80; Disc., 81–84, 1921. Engineering, 112. pp. 453–456, Sept. 23, 1921.—Abstract.)—In some of the copper-rich, Ni-Al-Cu alloys, the $\alpha$ solution will retain much more Ni and Al at 900° than at ordinary temperatures, and the present paper deals with the properties of the alloys comprised between the limits of composition of the $\alpha$ solution at 900° and at ordinary temperatures. The alloys used contained between 85 and 90 % Cu, 4·6 and 7·3 % Ni, and 5·2 and 7·9 % Al. These alloys, while relatively soft on quenching from 900°, are hardened by slow cooling from that temperature or by reheating to lower temperatures. This change in properties is the result of the appearance of a new constituent, the separation of which is accompanied by changes in the density and electrical conductivity of the alloy in addition to its effect on tensile, hardness, notched bar, and other tests. The separation of this special constituent takes place somewhat slowly, so that the chill cast alloys and hot-rolled rods of small section consist almost wholly of the α constituent. In this condition the alloys can be cold-rolled, though if cold rolling of the slowly cooled alloys is attempted, they crack badly. If annealing is required during cold rolling, the alloy must be heated to 900° and cooled rapidly in air or water. The cold-rolled rod presents some features of interest on low temperature annealing. Softening proceeds very slowly up to 500°, at which temperature precipitation of the Ni-Al rich constituent begins to take place at an appreciable rate, with the result that with some compositions, a progressive increase of hardness is obtained by holding the alloy at 500°. The rate of cooling from a temperature above that at which the α solution begins to deposit the special constituent has a great influence on the mechanical properties of the heat-treated alloys. The hardest product is obtained by reheating the quenched alloy to 600° for two hours or to 700° for half an hour. The alloys so treated generally give better properties than are obtained by any uniform rate of slow cooling; *e.g.*, yield-point, over 20 tons, max. stress over 40 tons per sq. in., elongation 15 to 25 %. The fatigue limits to alternating stress are much higher than the tensile elastic limits in the quenched alloys, but in the quenched and tempered alloys they are approximately the same as the elastic limit in tension. The heat-treated alloys show considerable endurance under alternating stress above their true fatigue limit, the determination of which involved a number of prolonged tests, as they may remain unbroken after 3 to 4 million alternations at stresses appreciably above their true fatigue limits.

C. O. B.

**1410.** *Rates of Reaction in Certain Steels at 930° C.* **E. D. Campbell** and **B. A. Soule.** (Iron and Steel Inst., J. 102. pp. 281–286, 1920.)—Deals with the thermoelectric e.m.f. produced by the difference in the rate of cooling of the two ends of a bar, due to the changes in constitution caused by such difference. L. H. W.

**1411.** *Aluminium Alloys: Eleventh Report of Alloys Research Committee.* **W. Rosenhain, S. L. Archbutt,** and **D. Hanson.** (Inst. Mech. Eng., Proc. 2. pp. 699–771, 1921. Engineering, 112. pp. 613–615, Oct. 28, and pp. 644–645, Nov. 4, 1921. Rev. de Mét. 19. pp. 44–58, Jan., 1921.)

**1412.** *Properties of Steel; Force Field Dissociation Theory of Solution Applied.* **E. D. Campbell.** (Faraday Soc., Trans. 16. pp. 554–558; Disc., 559–569, July, 1921.)

**1413.** *Electrochemical Behaviour of Mixed Crystals of Gold with Copper and Silver.* **G. Tammann.** (Zeits. anorg. Chem. 112. pp. 233–243, Sept. 14, 1920.)—Further experiments on the limiting compositions of alloys Au Cu and Au-Ag and their relations to the grouping of the components in the space-lattice. The measurements are made by electrolysing anodes of the alloys in $CuSO_4$ or in sulphuric or nitric acid. Within the range 1·0 to 0·5 mol. Au there is only a slight difference (of 0·1 volt) between the decomposition potential, at which electrons are discharged in appreciable quantities at the anode, and the potential at which the opposite current sets in. On further lowering the Au proportion this difference increases greatly. The author suggests that the electrons have preferential paths in the lattice. H. B.

**1414.** *Effect of Load on Gun-Metal.* **R. T. Rolfe.** (Inst. of Metals, J. 26. pp. 85–106; Disc., 107–137, 1921. Engineering, 112. pp. 580–583, Oct. 21, 1921.—Abstract.)—The effect of lead on the mechanical properties of two kinds of gun-metal are described. 1. *Admiralty Gun-Metal.*—In the case of sand castings the addition of lead up to about 1·5 % to Admiralty gun-metal slightly raises the ultimate strength and yield-point, and very considerably raises the elongation, while it causes a considerable drop in the hardness. The Stanton figure rises slightly at first and then falls. With further additions of lead, the effect is reversed. In the case of chill castings, the addition of lead has very little effect. 2. *Gun-Metal containing* 85 % *Cu,* 5 % *Sn,* 10 % *Zn.*—The addition of lead up to 2 % causes a slight fall in ultimate strength and the yield-point of this metal, both sand and chill cast, and a marked increase of the ductility of the sand-cast specimens. In the case of the chill-cast metal the ductility rises to a maximum with the addition of 1 % Pb, and then falls off rapidly. J. L. H.

**1415.** *Plastic Deformation of Copper Alloys at Elevated Temperatures.* **C. A. Edwards** and **A. M. Herbert.** (Inst. of Metals, J. 25. pp. 175–199; Disc., 200–218, 1921. Engineering, 111. pp. 341–344, March 18, 1921.)—Gives the results obtained with the instrument designed for making indentation tests under dynamic stresses [Abs. 886 (1918)] on Cu-Zn alloys at temperatures from 850° to 16° and on Cu-Al alloys from 900° to 16°. In the case of copper-zinc alloys containing 29·37 and 34·9 % Zn, the calculated Brinell numbers remain almost unchanged between 16° and 600°, and from 600° to 850° there is a fairly steady decrease from about 58 to 43; at the ordinary temperature, both of these consist only of $\alpha$ constituent. With the alloy containing 39·12 % Zn, which contains $\alpha$ and $\beta$ constituents at the ordinary temperature, there is a slight increase in plasticity up to temperatures approaching 450° C., but immediately above this the softening is much more pronounced and the Brinell number steadily falls from 76 at 450° to below 30 at 850° C. With alloys containing 43, 47, and 52 % Zn, the plasticity is practically the same for temperatures between 850° and 600°, then there is an abrupt change corresponding with a decrease in plasticity down to 450° C. The presence of the marked change in plasticity that occurs at about 450° in all Cu-Zn alloys which contain more than 30 % Zn makes it quite evident that this is associated with the $\beta$ constituent and the thermal critical point it possesses at 470° C.

C. O. B.

**1416.** *Constituents Found in Tungsten and Molybdenum Steels.* **A. M. Portevin.** (Iron and Steel Inst., J. 104. pp. 141–144, 1921. Engineering, 112. pp. 372–373, Sept. 9, 1921.)—In a steel with 0·4 % C and 5·4 % W quenched at 1300° C. and cooled in 75 hours is found a constituent occurring in needle form which is darkened by sodium picrate. Since this also occurs with only 0·1 % C and 7·55 % W it is considered to be $Fe_2W$ which has separated from a solid solution in Fe. Coincident with $Fe_2W$

may occur ferrite and carbide. The steel etched with Benedicks' reagent shows also a troostite constituent.

In the Mo steels a constituent similar to the Fe$_2$W is found under similar heat-treatment. F. C. T.

**1417.** *Working and Annealing of Copper.* **F. Johnson.** (Inst. of Metals, J. 26. pp. 173–197; Disc., 198–202, 1921. Engineering, 112. pp. 899–901, Dec. 30, 1921.—Abstract.)—I. It is shown that, in a series of copper strips which have been cold-rolled by varying amounts, the hardness and the density do not rise steadily with the amount of reduction, but that the metal appears to undergo alternate periods of softening and hardening.

II. A series of strips were rolled so as to reduce them by amounts varying from 18 % to 98 %, and were subsequently annealed at various temperatures. Annealing for one hour at 200° C. produces unmistakable softening in all strips reduced more than 40 %. At 250° C. some of the very severely rolled strips appear to be completely annealed, while accelerated softening sets in with about 45 % reduction. At 300° C. the accelerated rate of softening sets in at about 26 % reduction, while at 350° C. the increase of strength conferred by rolling has been almost completely removed.

III. Tough-pitch arsenical copper rods which have been reduced 60 % in area by cold drawing, retain their strength after annealing at 300° C., whereas non-arsenical rod has undergone considerable loss of strength. J. L. H

**1418.** *Selective Corrosion and Dezincification in Brass.* **F. de Wurstemberger.** (Rev. de Mét. 18. pp. 687–712, Nov., 1921.)—The author has studied a number of tubes from condensers, both of English and German manufacture, as a result of which he states that selective corrosion is an electrochemical process, and that dezincification is the result of two closely allied phenomena: an anodic solution of the metal, on the one hand, and a kathodic deposition of copper on the other. J. L. H.

**1419.** *Properties of Alloys (Brass) Prepared by Fusion and Electrolytically Deposited.* **F. Sauerwald.** (Zeits. anorg. Chem. 111. pp. 243–279, Aug. 9, 1920.)—The brasses contained from 18·4 to 100 % of Cu. The chemical and electrochemical properties studied are: attack by acids and metallic salts, and the e.m.f. against zinc chloride at various concentrations and temperatures. According to Tammann the properties of mixed crystals depend upon two factors, the distribution of the components and the mobility of the atoms in the space-lattice, the latter influenced by temperature. The copper may or may not protect the zinc in the lattice. In the alloys prepared by fusion the properties do show the protective action of the copper at ordinary temperature, and do not vary with the concentration; as crystals of a new lattice appear, the properties change suddenly; at 380° the mobility is sufficiently large, and the e.m.f. then changes with the concentration. In the electrolytically deposited alloy, the distribution of the components is more a matter of chance, and the electrochemical properties depend entirely upon the concentration. That the atomic distribution resulting from electrolysis is also a function of the temperature of preparation, however, is shown by the electrolysis of fused salts at 300°; the crystals then obtained are very nearly in the equilibrium condition. It is further shown that the composition of the brass deposited is influenced by the current density and the composition of electrolytes consisting of sulphates or potassium cyanides. H. B.

**1420.** *The Binary System Lead-Bismuth.* **W. Herold.** (Zeits. anorg. Chem. 112. pp. 131–154, Sept. 14, 1920.)—This system has been much investigated, and the author studies in particular the limits of the eutectic range in carefully annealed specimens by the aid of electric conductivity, hardness, and metallography. The conductivity (between 0° and 123°) indicates that up to 18·5 % Bi is soluble in Pb, and 1·6 Pb in Bi at 0°. The Brinell hardness tests give less certain values. Metallographically no eutectic was discernible in an alloy of 40 % Bi after reheating to 124° for 8 hours, whilst alloys richer in Bi still contained the eutectic, even after 30 hours. The limit of the eutectic is 40 % Bi; the research remained incomplete. H. B.

**1421.** *Relative Densities of Alkali-Metal Amalgams and Mercury.* II. **E. C. Bain** and **J. R. Withrow.** (J. Phys. Chem. 25. pp. 535–544, Oct., 1921.)—Potassium, sodium, and ammonium amalgams have been prepared in various ways and observations made on the densities of the solid amalgams relative to those of the liquid or solution phase in contact with them. The results furnish experimental confirmation of the deductions previously made on this subject. Contrary to the statements made by Kerp (Zeits. anorg. Chem., 1898, 17, 300) and Abegg (*Handbuch der anorganischen Chemie*, 1905, 2, II, p. 579), it is found that the solid amalgams produced by Kerp's and other methods are specifically lighter than their liquid contact phase. The oily and pasty consistencies sometimes observed with liquid amalgams are shown to be due to the incorporation of fine crystals in the liquids. T. H. P.

**1422.** *Zinc Alloys with Aluminium and Copper.* **W. Rosenhain, J. L. Haughton,** and **K. E. Bingham.** (Inst. of Metals, J. 23. pp. 261–317; Disc. and Comm., 318–324, 1920.)—The constitution of the zinc-rich alloys is briefly described. Tables and diagrams are given showing the rolling properties of the alloys, and the mechanical properties of the cast, cold-rolled, and hot-rolled alloys. The ageing properties of certain samples are described. Abnormal mechanical properties of some of the alloys are also discussed. J. L. H.

**1423.** *Temper Brittleness of Nickel-Chrome Steels.* **R. H. Greaves** and **J. J. A. Jones.** (Iron and Steel Inst., J. 102. pp. 171–218; Disc. pp. 219–222, 1920.)—An investigation on some Ni-Cr steels in order to discover the temperature range and the rate of production of temper brittleness and the susceptibility of certain steels to this brittleness, together with a study of the effect of the change from the brittle to the tough condition on a few of the physical properties of the steel. The range in which the brittleness occurred was found to be roughly 585° to 475° C. in acid open-hearth steels and 550° to 450° C. for electric steels. It was found that in Ni-Cr steels those produced in the acid open-hearth furnace were more susceptible to temper-brittleness than those produced by the electric furnace, while these, in turn, were more susceptible than crucible steels of the same composition. A suggestion is advanced by the authors that temper brittleness may in some way be due to the presence of an oxide of chromium in the steel. J. L. H.

**1424.** *Tin-Phosphorus Alloys.* **A. C. Vivian.** (Inst. of Metals, J. 23. pp. 325–360; Disc., 361–366, 1920.)—The constitution of the tin-phosphorus alloys is worked out, mainly by thermal analysis. The existence of the three compounds $Sn_4P_3$, $Sn_3P_4$, and $SnP_3$ is shown. Two ranges of conjugate solutions also occur. In the *discussion*, **J. L. Haughton** suggested certain modifications to the diagram to bring it into line with phase requirements. J. L. H.

**1425.** *Physical Tests on Sheet Nickel Silver.* **W. B. Price** and **P. Davidson.** (Chem. and Met. Eng. 25. pp. 141–148, July 27, 1921.)—Gives a survey of some of the physical properties of four samples of nickel silver, two low in Ni (6 %) and two high in Ni (18 %).

**1426.** *Constitution of Aluminium-Magnesium Alloys.* **D. Hanson** and **M. L. V. Gayler.** (Inst. of Metals, J. 24. pp. 201–227; Disc. and Comm., 228–232, 1920.)—The constitution of the alloys was investigated by means of thermal curves and by the microscopic examination of annealed specimens. In the determination of the solidus, the alloys were first annealed at a temperature close to that of the eutectic until equilibrium was attained, and then quenched in a Rosenhain furnace from varying temperatures. The results indicate the existence of the compound $Al_3Mg_2$ and another compound, which appears to be $Al_2Mg_3$; this, however, does not separate at a maximum point on the liquidus, but at a temperature a few degrees lower. There are three eutectics in the series, and both metals are soluble in each other to the extent of about 10 %. J. L. H.

**1427.** *Graphitisation of Iron-Carbon Alloys.* **K. Honda** and **T. Murakami.** (Iron and Steel Inst., J. 102. pp. 287–294, 1920.)—A pure white pig iron, containing 3·75 % C was melted in an electric furnace, and the influence on the degree of graphitisation of the following factors was studied: (1) Maximum temperature, and time of exposure to this temperature; (2) method of cooling; (3) special treatment during melting; (4) previous treatment; (5) annealing below the eutectic point. The following conclusions are drawn: (1) In pure iron-carbon alloys, graphitisation is caused by the decomposition of the cementite solidified during cooling from the melt. (2) Graphitisation is not a direct decomposition of cementite at high temperatures according to the equation, $Fe_3C = 3Fe + C$, but is caused by a catalytic action of CO or $CO_2$. J. L. H.

**1428.** *Colours of Tempered Steel.* **C. V. Raman.** (Nature, 109. pp. 105–106, Jan. 26, 1922.)—The correctness of the usual explanation of the colours of tempered steel has been questioned by Mallock [Abs. 1153 (1918)]. Recent observations by the author show that the colours complementary to the tints seen by reflected light appear as light *scattered* or *diffracted* from the surface of the metal. It thus appears that the colours appearing on the surface of a tarnishable metal, when heated in contact with air, are in the nature of diffraction effects arising from a film which is not continuous, but has a close-grained structure. Interesting effects are observed when the surface of the illuminated plate is viewed through a nicol, the colour and intensity of the scattered, as well as of the regularly reflected beams varying as the nicol is rotated about its axis. When the direction of observation is nearly parallel to the surface of the plate the scattered light is nearly completely polarised, and the colour of the regularly reflected light changes nearly to its complementary when the nicol is turned through 90°. The phenomena resemble Wood's observations discussed by Rayleigh [Abs. 154 (1918)], on the colours of a frilled collodion film on a silvered surface. A. W.

**1429.** *Macrographic Control of the Casting of Aluminium Bronze.* **J. Galibourg** and **A. Brizon.** (Rev. de Mét. 18. pp. 780–786, Dec., 1921.)—The copper-aluminium alloy with 10 % Al possesses very useful mechanical properties [see Abs. 267 (1917)]. The casting difficulties are, however, appreciable. The addition of 1–4 % Fe or Mn reduces the grain size, but contraction cavities are troublesome. To overcome these the use of chills is recommended where the thickness of the section is increased. It is better, however, only to use this alloy in the forged state. Hot forging presents no difficulties. F. C. T.

**1430.** *Influence of Protective Colloids on the Corrosion of Metals and on the Velocity of Chemical and Physical Change.* **J. A. N. Friend** and **R. H. Vallance.** (Chem. Soc., J. 121. pp. 466–474, March, 1922.)—On the lines of a theory developed in a previous paper [Abs. 1214 (1922)] experiments are carried out to study the retarding influence of protective colloids on the corrosion of metals. With various colloids retardations are quantitatively determined for iron, zinc, and lead, the last-named metal being particularly susceptible to colloid retardation. Sucrose behaves exceptionally, showing a pronounced accelerating action on the corrosion of iron and zinc, but a powerful retarding action on that of lead. The results are discussed in relation to the adsorption law. A similar series of experiments on the effects of protective colloids on the rate of dissolution of salts in water are described. A. B. C. L.

**1431.** *Nitrogen in Carburised Steels.* **W. E. Ruder** and **G. R. Brophy.** (Chem. and Met. Eng. 25. pp. 867–871, Nov. 9, 1921.)—Deals with the introduction of nitrogen into steel during case-hardening by the use of solid carburisers. The presence of nitrogen may frequently be detected by the nitride needles which are quite characteristic, but when it is present as a solid solution, or as a eutectoid (possibly between FeN and Fe), its presence may easily be overlooked. Heat-tinting gives a clue to its presence when dissolved in the ferrite, as ferrite grains containing dissolved nitride colour much more rapidly than pure ferrite. Stead's phosphorus reagent containing $CuCl_2$ is also useful for detecting the presence of nitrogen. Case-hardening appears to be of two kinds—(1) nitrogenising, when cyanide is used, either in the molten, gas, or cyanamide process; (2) carburising, when a solid or gaseous carburiser is used which does not contain too much of the nitrogen-bearing energisers. Nitrogenous materials are often added to commercial carburisers on the assumption that they aid the penetration of the carbon; it is shown, however, that this is wrong, and that the additional hardness obtained is due to combined nitrogen. This nitrogen penetrates deep into the specimen, and nitrogen needles are found inside the case proper. The brittleness caused by this nitrogen may well be the cause of numerous and perplexing cases of exfoliation. The results of experimental work on various special steels are given. Nickel up to 3 % appears to have no effect on the penetration of nitrogen, but the presence of the nickel increases the solubility of the ferrite for nitrogen and for the carbon present. In the case of chrome steels the penetration is about the same as with nickel; the concentration is greater, however, and may be due to the greater affinity of Cr for N or C, or both. Chromium appears to increase both the penetration and concentration of N and C. Vanadium is more active than Cr, and the concentration is greater. With manganese steel, the absorption of N is high, and of all steels experimented with these are the most brittle after cyanide treatment. C. O. B.

**1432.** *Calcium.* **P. H. Brace.** (Inst. of Metals, J. 25. pp. 153–168; Disc., 169–174, 1921. Engineering, 111. pp. 308–310, March 11, 1921. Chem. and Met. Eng. 25. pp. 105–109, July 20, 1921.)—A general article on the history, properties, alloys, and uses of the metal. It is best prepared by the electrolysis of fused $CaCl_2$, which must be quite free of water. The author has modified the Rathenau cell by inserting, from above, two water-cooled anodes, which are kept in horizontal and vertical movement; to start the electrolysis, an alternating current is passed between the tips of the anodes. The fused $CaCl_2$ must not be allowed to freeze. The addition of other halides to the bath is not advisable; calcium reduces the other metals, and forms with them brittle alloys of lower melting-point. H. B.

**1433.** *Physical Chemistry of the Oxides of Lead.* I. *Solubility of Lead Monoxide.* **S. Glasstone.** (Chem. Soc., J. 119. pp. 1689–1697, Oct., 1921.)—The suggestion that the yellow forms of lead monoxide are really agglomerates of small particles which are almost identical with the finely-divided red modification is confirmed by the results of solubility determinations in *N*-sodium hydroxide solution, and of microscopic examination. The energy at the surface of separation of lead monoxide and *N*-sodium hydroxide solution is calculated to be 1860 ergs per cm.$^2$ at 20°; this value changes comparatively little if the alkali solution is replaced by water. The dissociation constant of the acid $H . HPbO_2$, produced by dissolving lead oxide in water, is $1 \cdot 32 \times 10^{-12}$ at 25°. T. H. P.

**1434.** *Physical Chemistry of the Oxides of Lead.* II. *Supposed Enantiotropy of Lead Monoxides.* **S. Glasstone.** (Chem. Soc., J. 119. pp. 1914–1927, Dec., 1921.)—Previous authors have stated that two enantiotropic forms of lead monoxide (red and yellow) must be clearly distinguished, and transition temperatures have been given. The results of the author's measurements of the potential of the half-element, Pb/PbO *N*-NaOH, are, however, not in agreement with the existence of such enantiotropic modifications. The temperature to which the red form of lead monoxide must be heated in order that the yellow variety may be formed on cooling is found to vary in dependence on the state of division of the red oxide. The evidence based on crystallographic measurements of the two forms does not allow of any definite conclusion being drawn, and it seems likely that the difference in properties of the various forms of lead monoxide is to be explained on the ground of differences in the degree of sub-division or agglomeration.

The solubility product of red lead monoxide is found to be $1\cdot17 \times 10^{-15}$ at 25°, and its heat of formation, 49,610 cals. The dissociation pressures of oxygen derived from lead monoxide are calculated by various methods, which give good agreement, and the values of the e.m.f. calculated by Nernst's theorem accord well with the experimental values. T. H. P.

**1435.** *Determination of Chemical Constants from the Vapour-Pressures of Fused Cadmium and Zinc; Monatomic Bromine.* **H. Braune.** (Zeits. anorg. Chem. 111. pp. 109–147, July 1, 1920.)—The deduction of the constants from the vapour-pressures is recommended. The author determines the vapour-pressures of Cd and Zn after Wartenberg [Abs. 1848 (1913)] by heating the grains of the metal in a quartz tube, 1 cm. diameter, 70 cm. long, placed in an electric furnace and joined in it to a quartz capillary; hydrogen is passed over the metal. For the determination of the boiling-points a vertical quartz tube is used. The atomic heats were found to be practically constant for the range between boiling-point and melting-point, and the values, 7·5 for Cd and 7·24 for Zn, yield the constant 1·54 ± 0·2 for Cd and 1·11 ± 0·07 for Zn (instead of 1·489 and 1·136), which would be those of monatomic gases. In the case of bromine calculations are based on Bodenstein's dissociation experiments; as the specific heat of bromine at low temperatures is not known, the calculations are incomplete, but they support the assumed monatomic character. H. B.

**1436.** *Kinetic and Static Measurements of the Coagulation of Suspensoids.* **F. V. v. Hahn.** (Zeits. Elektrochem. 27. pp. 501–505, Nov. 1, 1921. Paper read at the Deut. Bunsen Gesell., Jena, Sept., 1921.)—Colloids may be classified as possessing a degree of dispersion in the range between $0\cdot1\,\mu$ and $1\,\mu\mu$. Particles above this range form coarse suspensions; those of smaller size, molecular solutions. The stability of a sol—which for a given substance is inversely proportional to the size of the dispersed particles—can be determined by a quantitative measurment of some agency required to produce coagulation or flocculation, such as by the action of an electrolyte, electro-endosmose, or by boiling. The kinetic and also the static methods which have been applied are described. J. N. P.

**1437.** *Volume-Changes by Mixing Liquids or by their Dilution.* **I[rene] Götz.** (Zeits. phys. Chem. 94. pp. 181–209, Feb. 27, 1920.)—It is sometimes assumed that whenever liquids do not behave simply like addition products on being mixed, there must be chemical reaction. But there may be an attraction between the different molecules, depending upon the nature of the liquid and the molecular distribution. The internal pressures of two different liquids will generally be different, and there will be changes on mixing and diluting. The author studies from this point of view first the thermal expansions of some organic compounds between 0° and 40° and at pressures up to 420 atmos., and then mixes the liquids or dilutes the solutions. The thermal expansion of mixtures of ethyl ether–ethylene dichloride and ethyl ether–benzene is found to be the same as that of ethyl ether under a definite external pressure. The calculations are based on Tammann's law of concentrated solutions. In the case of the dilution by ethyl ether of concentrated solutions of ethylene dichloride in ethyl ether the observed contractions are in agreement with the calculations ; this applies also to the mixing of ethyl ether and benzene, though not to all the cases studied. H. B.

**1438.** *Study of the System Ammonia–Water as a Basis for a Theory of the Solution of Gases in Liquids.* **B. S. Neuhausen and W. A. Patrick.** (J. Phys. Chem. 25. pp. 693–720, Dec., 1921.)—The two principal dynamic methods for investigating the composition of the vapour phase of binary liquid mixtures are both open to serious objections, and the authors have developed a static method for measuring partial pressures based on the following considerations. The fixed total pressure of a solution of a certain definite composition of A and B is made up of the partial pressures of A and B. If B is assumed to have a greater vapour pressure than A, and that by some means a quantity of vapour of A is forced into the vapour phase of the system, the partial pressure of A is exceeded and some of it will condense. As some of the vapour of B also will dissolve in this condensate, a readjustment will occur, and a solution will be obtained somewhat less concentrated with respect to B, the partial pressure of B being appreciably diminished and that of A slightly increased. The system will therefore undergo a lowering of the total pressure, since the volume is not changed appreciably by the minute quantity of condensate. Further, if water-vapour is added gradually to gaseous ammonia at a certain temperature and pressure below that corresponding with the vapour pressure of liquid ammonia at that temperature, the pressure of the mixture will rise until the partial pressure of the water-vapour equals that corresponding with the partial pressure of water-vapour over a solution whose partial pressure of ammonia at that temperature is the same as at first. Any further addition of water-vapour will entail condensation of water with consequent dissolution of ammonia and reduction of the total pressure. This method has been used to determine the partial pressure of water, to within 0·08 mm. and that of ammonia, to within 4–2 mm., of concentrated ammonia solutions at 0°, 20°, and 40°, and at partial pressures of ammonia varying from 1000 to 4000 mm. If V represents the volume occupied by the liquefied gas dissolved per gm. of water, $P_0$ the vapour pressure, $\sigma$ the surface tension of the liquefied gas, and P the equilibrium gas pressure, the formula $V = K(P\sigma/P_0)^{1/n}$ is found to represent well the solubility of ammonia, hydrogen chloride, $SO_2$ and $CO_2$ in water at varied temperatures and pressures. For ammonia the values of K and $1/n$ are respectively 0·49 and 0·69.

T. H. P.

**1439.** *Solubility of Small Particles and the Stability of Colloids.* **L. F. Knapp.** (Faraday Soc., Trans. 17. pp. 457–494 ; Disc., 494–498, Feb., 1922.)—The stability of many colloids appears to be connected with the electric charge carried by the disperse phase. In this paper an attempt is made to explain this relation by consideration of the influence of the electric charge on the solubility of the particles. L. H. W.

**1440.** *Solubility of Radium Emanation in Organic Liquids.* **A. Schulze.** (Zeits. phys. Chem. 95. pp. 257–279, Aug. 13, 1920.)—In order to test Dolezalek's theory of gas solution the author determines the solubility of radium in water and in a considerable number of organic compounds, ether, alcohol, chloroform, acetone, carbon disulphide, ethylacetate, benzene, toluene, aniline, etc. Qualitatively the theory is confirmed; a quantitative confirmation is almost impossible in view of the small quantities available. But the vapour tension data of the emanation admit of drawing some conclusions, and it is, on the other hand, possible to obtain information as to the molecular weight of the solvent from the trend of the solubility curves at different temperatures. H. B.

**1441.** *Ghosh's Theory of Electrolytic Solutions.* **C. A. Kraus.** (Am. Chem. Soc., J. 44. pp. 2514–2528, Dec., 1921.)—It is concluded that in its present form Ghosh's theory does not account satisfactorily for the properties of such solutions. L. H. W.

**1442.** *Thin Films of Mixtures of Glycerides.* **P[aule] Collet.** (Comptes Rendus, 174. pp. 544–545, Feb. 20, 1922.)—A study of the spreading over water of thin films of a series of solutions of various glycerides in benzene, and mixtures of such solutions. J. S. G. T.

**1443.** *Chemical Constants of Sodium and Potassium.* **R. Ladenburg** and **R. Minkowski.** (Zeits. f. Physik, 8. 2. pp. 137–141, 1921.)—With the help of some optical measurements of relative vapour pressures of Na recently communicated by the authors [see Abs. 1160 (1922)] and some direct vapour-pressure measurements by Huber and Zisch, it is now possible to calculate the chemical constant (C) of Na with some accuracy. The specific heats of Na down to 50° abs. are also known from some recent measurements. These quantities are less well known in the case of potassium, so that the uncertainty of its chemical constant is greater.

For the calculation of C a well-known equation of Nernst and Stern is employed, leading to the value $C = 0\cdot846$ for Na. It is known that $C = C_0 + 1\cdot5 \log M$, where M denotes the molecular weight and $C_0 = -1\cdot59$. Taking M in the case of Na as $23\cdot00$, we obtain $C_0 = -1\cdot20$, a discrepancy which must be due to the inaccuracy of the data employed. Exact measurements of the vapour pressure of Na at low temperatures, and of its specific heat at both low and high temperatures, are urgently required.

In the case of potassium, using certain data, the value $C_0 = -1\cdot37$ is obtained. T. B.

**1444.** *Viscosities of the Hydrogen Halides.* **H. Harle.** (Roy. Soc., Proc. 100. pp. 429–440, Jan. 2, 1922.)—The measure of agreement between the values of the atomic diameter obtained from Bragg's crystal measurements and those deduced from viscosity data and the kinetic theory of gases has recently been demonstrated by Rankine for the gaseous halogens, in which the two atoms of the molecule are of equal size. The mathematical treatment by which the mean collision area is deduced may be extended to molecules compounded of two unequal atoms, such as those of the hydrogen halides, and the author has now measured the viscosities of these gases with the object of furnishing a test of the further theoretical investigation of Rankine [Abs. 1667 (1921)]. The chemical activity of the gases limits the possible modes of measuring the viscosity, the method chosen being that of the transpiration of the gases through a capillary tube, the dimensions of which were obtained by the transpiration of air. The purified gases were first liquefied and then enclosed and allowed to evaporate, the process of evaporation being controlled so as to establish a suitable driving pressure and the pressure difference between the ends of the capillary being observed on a liquid U-tube gauge. The masses of gas passing were measured by absorbing in water and titrating with standard alkali. The measurements were made at two temperatures about 85 deg. apart and the value of Sutherland's constant C then calculated. The results obtained are summarised in the following table:—

| | $\eta_0 \times 10^4$. | $\eta_{100} \times 10^4$. | C. |
|---|---|---|---|
| HCl ............... | 1·332 | 1·837 | 357 |
| HBr ............... | 1·710 | 2·365 | 375 |
| HI ............... | 1·731 | 2·403 | 390 |

T. H. P.

**1445.** *Structure of Liquid Mixed Crystals capable of Drop-formation.* **O. Lehmann.** (Ann. d. Physik, 66. 5. pp. 323–343, Jan. 10, 1922.)—The structures of liquid crystals of a number of different compounds have been investigated by means of the polarising microscope, the appearances observed being depicted and described. Like solid crystalline substances, these crystalline liquids must be regarded as aggregates of numerous individual crystals, which assume regular form and structure. Further, just as with solid crystalline materials, liquid crystals exhibit no distinct limits between the individuals, and, moreover, the structure of a liquid crystal may be extremely different from that of an ideal solid crystal in spite of complete chemical homogeneity. T. H. P.

**1446.** *Lubricating Properties of the Various Series of Hydrocarbons. Preliminary Report.* **W. F. Seyer.** (Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 69–71, 1921.)—The chief constituents of lubricating oils belong to the series $C_nH_{2n}$, $C_nH_{2n-2}$, and $C_nH_{2n-4}$, representing either saturated naphthenes or olefines, both of which are present in most lubricating oils. To determine which series possesses the better lubricating properties experiments were carried out in which the saturated and unsaturated constituents of a typical lubricating oil were separated by liquid $SO_2$ extraction and tested in an Olsen friction machine. The results are tabulated and discussed in relation to the respective viscosities. It is shown that the coefficient of friction is not independent of the chemical nature of the oil. Carbonisation is noted in the case of the unsaturated oil, although the temperature is not raised above 35° C., but, with the oil investigated, the unsaturated portion possesses the better lubricating properties. A. B. C. L.

**1447.** *Electro-Osmosis and the Chemical Properties of the Diaphragm.* **S. Glixelli.** (Akad. Wiss. Krakau, Anz. pp. 102–128, 1917 [A]; Chem. Zentrbl. III. p. 431, 1920.)—The author maintains that the potential $\phi_1$ of the mobile layer of the liquid is not the same as that of the liquid $\phi_a$ attached to the wall of the diaphragm. The difference $(\phi_1 - \phi_a)$ of the electric double layer is proportional to the rate of electro-osmosis or cataphoresis. The cause of this difference and the mechanism of the phenomenon are investigated by the study of the changes produced by the addition of electrolytes. The author's method of determining the isoelectric point enables him to work with fairly concentrated solutions of electrolytes, 0·5 N, and with gels and powders of acids, oxides, and hydroxides of Si, W, Sb, Sn, Zn, Fe, Ag, etc. As regards the concentration of the hydrogen ion at the isoelectric point, the substances examined may be classed as acids, acid or basic ampholytes, and bases. The theoretical discussion concerns the origin of the electric charges of colloidal particles. H. B.

**1448.** *Transference Numbers of Sulphuric Acid by the Concentration Cell Method.* **A. L. Ferguson** and **W. G. France.** (Am. Chem. Soc., J. 43. pp. 2150–2160, Oct., 1921.)—The determination of transference numbers by the concentration cell method involves measurement of the potentials of (1) a concentration cell without diffusion, (2) a concentration cell with diffusion and reversible with respect to the kation, and (3) a concentration cell with diffusion and reversible with respect to the anion. This method, which was shown [Abs. 1095 (1916)] to be more accurate in the case of uni-univalent electrolytes than the Hittorf method, is now found to apply equally well to the uni-bivalent electrolyte, sulphuric acid. The experimental methods employed are fully described.

The transference number of the anion of sulphuric acid for concentrations between 0·1 M and 0·01 M has the value 0·1868 ± 0·0007 at 25°. For calculating the potentials of concentration cells, dissociation values determined from freezing-point data are shown to be more satisfactory than those derived from conductivity data. For the formula for the potential of a concentration cell a correction has been developed, which takes into account the undissociated portion of the acid. T. H. P.

**1449.** *Photochemical Dye Cells.* **E. Staechelin.** (Zeits. phys. Chem. 94. pp. 542–591, May 4, 1920.)—Continuing the work of E. Baur, Trümpler, Titlestad, and others, and referring also to Swensson, the author studies the potential against a calomel electrode, under illumination by a half-watt lamp of 3000 c.p., of aqueous solutions (sometimes acidified) of various pure dye-stuffs: rhodamines, eosin, phosphors, resorufin (colloidal), also quinine sulphate in large **U**-tubes. Various oxidising or reducing agents, organic and inorganic, were added to the solutions. Potentials are measured by compensation. The electrodes were mostly Pt gauze, up to 1200 mm.$^2$ in area. The effect may take place in either direction, and is influenced by oxidising or reducing agents. The behaviour of all the substances can be explained by the assumption of a marked photolytic decomposition of water. The light does not really modify the sensitive substances, it is suggested, but the absorption of a quantum leads to the stretching (Spreizung) of one or more electrons; the molecule should then occupy a larger volume, which would accord with the views of Weigert and of Stern and Vollmer on the decay of fluorescence. H. B.

**1450.** *Potential of the Thallium Electrode and Free Energy of Formation of Thallous Iodide.* **G. Jones** and **W. C. Schumb.** (Am. Acad., Proc. 56. pp. 199–236, April, 1921.)

**1451.** *Reactions of the Lead Accumulator.* **D. A. MacInnes, L. Adler,** and **D. B. Joubert.** (Am. Electrochem. Soc., Trans. 37. pp. 641–648; Disc., 648–651, 1920.)—An experimental study of the amount of sulphuric acid consumed during the discharge of a lead accumulator, in order to determine whether two or one gm. equivalents of acid disappear per faraday passing, in order to decide between Gladstone and Tribe's formula for the chemical reaction or that advanced by Féry. The results were intermediate of the two. Careful chemical analyses of the oxide formed during charging show it to be certainly $PbO_2$. The chemical potential of the oxide on the positive plate was also found to be identical with that of chemically prepared $PbO_2$ and electrically precipitated $PbO_2$. It is suggested tentatively that intermediate oxides, such as $Pb_3O_4$, or basic compounds, such as $(PbO)_x . PbSO_4$ may be formed during discharge.

AUTHORS.

**1452.** *Electro-deposition of Cobalt.* **B. Carr.** (Faraday Soc., Trans. 16. pp. 488–489; Disc., 489–491, July, 1921.)—The bath used in the experiments described was prepared by dissolving 2·5 oz. of sodium chloride and then 4·5 lbs. of crystalline cobalt sulphate in a solution of 5 oz. of boric acid in 5·5 pints of boiling water, and was used at 34° with stationary electrodes. The bath should be clear, any excess of undissolved boric acid being removed by filtration, and the surface of the kathode must be perfectly clean and smooth, since any imperfections show clearly after the deposition of the cobalt. "Quicking" in a solution of mercuric cyanide results in no appreciable improvement. Only the thinner deposits of cobalt are adherent, the thicker ones beginning to blister either spontaneously, or under slight bending stresses. As regards the influence of the composition and surface of the basis plate, good deposits are obtained on buffed or polished brass or copper, and on brass plate coppered in alkaline copper bath, but the deposit formed on nickel peeled off. The deposits are obtained very quickly, and they polish well and, although thin, exhibit no tendency to expose the metal beneath; they are very hard and remarkably resistant to atmospheric corrosion.

T. H. P.

**1453.** *Electrolytic Concentration of Aqueous Solutions of Nitric Acid.* **H. J. M. Creighton.** (Frank. Inst., J. 193. pp. 89–95, Jan., 1922.)—Electrolytic concentration of aqueous nitric acid solutions may be effected in the anodic compartment of a cell, which is separated from the katholyte by means of a porous diaphragm. The changes which occur in the anolyte during the passage of F faradays of current through the electrolyte are as follows: F gm. of ions of $NO_3$ discharge and react with the water in accordance with the equation: $2NO_3 + H_2O = 2HNO_3 + O$. This decomposition leads to the elimination of some water, and the concentration is further enhanced by the migration of 0·15 gm. of ions of $NO_3$ into the anode section, 0·85 gm. of ions of hydrogen, migrating at the same time into the kathodic section. The hydrogen liberated reacts with the nitric acid. By arranging the conditions so that oxides of nitrogen only are yielded and by leading these gases into the anode section of the cell, reaction takes place in the presence of water and nascent oxygen to give nitric acid, thus increasing further the concentration of the anolyte. In an experiment in which an unglazed porcelain cylinder was used to contain the anolyte, surrounded by the katholyte in a glass cylinder, the electrodes being of Pt, the kathodic c.d., 5–8 amps./dm.$^2$, the temperature 5–10° C., and leading the oxides of nitrogen from the kathode chamber into the anolyte, a solution containing 71 % $HNO_3$ was increased to 92·2 % in 51 hrs. An energy expenditure of 1·2 kw.-hrs. was required

for a final weight of anolyte of 1210 gm. The p.d. between the electrodes varied from 3·4 volts at the beginning to 6·5 volts at the end of the electrolysis. In a further experiment in which the $NO_2$ was not led into the anolyte, acid of 92·2 % strength was raised to a concentration of 99·65 % $HNO_3$. In this latter stage the temperature was kept below 8°, and 0·3 kw.-hrs. of energy was consumed per 350 gm. of anolyte.
J. N. P.

**1454.** *Overvoltage. I. Comparison of the Methods of Determination; the Mercury Kathode.* **S. Dunnill.** (Chem. Soc., J. 119. pp. 1081–1088, July, 1921.)—A layer of mercury is placed in a crystallising dish and connected as kathode with a source of current by contact with a Pt wire. An anode of Pt wire is suspended in the electrolyte of *N*-sulphuric acid above the mercury. With currents exceeding 50 milliamps. a circular area of mercury free from bubbles appears below the anode. This area widens with increasing current density, and in it a circulation of mercury outwards from the centre is seen to occur. This electrocapillary effect is attributed to the fact that the centre of the mercury receives a higher current than the outside, whereby a higher potential results, which leads to a lower surface tension and a continuous dragging outwards of the mercury at the centre. The effect of this phenomenon on overvoltage is ascertained by the commutator method, in which a measurement is made of the back e.m.f. during intervals varying from 0·01 to 0·02 sec. after interruption of the electrolytic circuit. The e.m.f. is found to fall with increasing current density, and, as would be expected from the mobility of the mercury surface, with an increase in the duration of the intervals of interruption. With a current density of 36 milliamps., the overvoltage amounts to 0·75 volt for an interval of 0·02 sec., 0·85 volt for an interval of 0·01 sec., while the potential measurement made directly during electrolysis was 1·14 volt.

The directly measured values are steady with time, accurately reproducible, and are considered to provide the most satisfactory determination of overvoltage. With an amalgamated lead kathode an increase in the overvoltage as measured by the commutator method was also found to result from decrease in the interval of interruption. It is inferred from this that the overvoltage decays too rapidly for any decision to be made as to the true value by means of the commutator method. J. N. P.